Low-Cost Science Teaching Equipment

Report of a Commmonwealth Regional Seminar/Workshop

Nassau, Bahamas, 16-26 November, 1976

Commonwealth Secretariat

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INTRODUCTION

The importance of science to national development has been recognized by all governments. This is evident from the worldwide trend towards developing relevant materials which are related to a child's environment.

In general, the materials developed during the past two decades have tended to stress student participation and learning by doing. Consequently, they require an adequate supply of equipment for effective implementation. Yet, to date, very little progress seems to have been made in school science teaching. One of the major reasons is the non-availability, inadequacy or non-utilization of equipment. Hence Commonwealth governments have requested that the Commonwealth Secretariat should promote and encourage co-operative activities aimed at alleviating this handicap.

In September 1975, the Secretariat published a book entitled The Production of School Science Equipment. Besides critically reviewing developments in the field of low-cost equipment, the book provides information on agencies and programmes concerned with the design and manufacture of science teaching aids in a wide range of countries. Also included are photographs of many types of equipment for use in countries where items from the major international suppliers are unobtainable or unsuitable.

This seminar - the first of a series of such meetings on the teaching of science - was organized to complement our publishing efforts in the field of science equipment. It did not concern itself with the methods of teaching science. Instead, it emphasized the means of making the knowledge of science available to as many school pupils as possible through the local production of science teaching equipment, keeping the cost as low as possible. For this reason, the seminar included practical laboratory sessions at which participants familiarized themselves with basic workshop techniques for the construction of some of the simple basic items of equipment which are at present imported into the various countries. Participants produced some equipment themselves.

Ways of identifying regional and Commonwealth co-operation was another objective of the meeting, and a number of recommendations were made. It is hoped that these recommendations will result in practical programmes and projects that will assist Commonwealth Caribbean countries in making their science education programmes more effective.

The Commonwealth Secretariat wishes to acknowledge its gratitude to the Government of The Bahamas for playing host to this seminar/workshop and to all those who contributed to the meeting and offered hospitality to the delegates. Special thanks are due to the Chairman, Miss Marjorie Davis, who steered the sessions so ably, to our consultants, to whom the success of the laboratory sessions was due, and to our resource person and the observers who also contributed effectively to the work of the seminar.

SEMINAR/WORKSHOP RECOMMENDATIONS

1. Commonwealth Caribbean Governments are requested to:

   (a) Ensure that all who are involved in education are familiar with national educational aims and objectives, since not much can be done by way of making education relevant to the needs of a country until educational aims are clarified.

   (b) Establish curriculum development units, where this has not already been done, to ensure that what is taught in educational institutions is relevant to the needs of society.

   (c) Establish production units for the production of textbooks, science equipment and other learning and teaching materials to support curriculum renewal programmes.

   (d) Support the teaching of science at all levels of education by making adequate provision for teachers and equipment, so as to provide a solid foundation for training scientists, technicians and technologists.

   (e) Provide facilities for regular in-service training of teachers.

   (f) Encourage the free flow of science equipment among the Caribbean and other Commonwealth countries, through relaxing import and other regulations.

2. The Commonwealth Secretariat is requested to:

   (a) Circulate information on developments in the field of school science equipment, and compile a directory of commercial kits and literature about their use.

   (b) Assist, when requested, with programmes of in-service training of teachers and with the running of national or regional science workshops.

   (c) Organize at the earliest opportunity a Commonwealth Specialist Conference on the teaching of science.

   (d) Provide bursaries for persons working in science education to enable them to receive training at suitable centres for the production of science equipment.

   (e) Provide information on the establishment, organization and equipment of resource centres.

   (f) Provide information about the equipment, organization, and management of teacher centres.

(g) Assist with the provision of up-to-date information about Commonwealth countries to facilitate teaching about the Commonwealth.

(h) Review its system of disseminating information to ensure that the information also gets to institutions, organizations and individuals who need it.

3. National and international organizations and agencies in association with the Commonwealth Secretariat, where appropriate, should consider encouraging and providing assistance for national and regional programmes relating to the local production of school science equipment.

4. In association with the Caribbean Regional Organization of Associations for Science Education, universities and other appropriate regional bodies, CARICOM should:

(a) Encourage the formation of national science teachers' associations in all Commonwealth Caribbean countries.

(b) Establish a clearing house for information on the design and production of school science equipment.

(c) Establish a regional co-ordinating or monitoring unit to advise and make recommendations on local production of science equipment, encourage relevant local activity, and determine the feasibility of setting up regional, sub-regional or local production units.

(d) Encourage regional co-operation through standardization, production and distribution of locally produced science equipment.

SUMMARY OF DISCUSSIONS

THE STATE OF SCIENCE TEACHING IN COMMONWEALTH CARIBBEAN SCHOOLS

In order to achieve a good exchange of information at this seminar/workshop, participating governments were asked to provide country papers on the state of science education in their countries. In general, these papers dealt with the status of science education at the primary, secondary, and teacher training levels. They were presented by representatives of the various countries during the first two plenary sessions of the meeting.

Among other things, the difficulties and problems which Caribbean countries encounter in their efforts to equip their school science laboratories, and the attempts of the various Ministries of Education and other bodies in the development of locally produced items of equipment were highlighted.

Primary School Level

Until recently, the type of science taught in the majority of the countries was "Nature Study". Although most countries suffer from lack of a common policy for science teaching in their primary schools, it appears that attempts are being made in some of the countries to develop and introduce into their school systems a structured science programme which is related to their local environment.

Professional support has been or is being given in most territories by science specialists from the secondary schools, teachers' colleges, and officers of Curriculum Development Units where such bodies exist, and by advisers from such agencies as UNESCO, UNICEF and the British Council.

Most of the programmes already being developed are discovery method oriented; they involve experimentation by pupil participation and consequently require an adequate supply of equipment. Unfortunately, however, basic equipment needed for this type of approach to science learning is sparse or, as in most cases, non-existent. Most primary school teachers have had little or no special training in teaching science at this level. As a result of this poor background in science, teachers lack the confidence, knowledge and the skills that are necessary for effective science teaching, and are unable to identify potential sources in their environment that might be used in the classroom for teaching the subject. Hence the improvization which ought to be a common feature of science teaching is often absent. It is only in recent years that attempts have been made to make science a compulsory subject in the first year of most of the primary teacher education programmes in the teacher training colleges. Even now, though science programmes are compulsory for first year students in almost all teacher training colleges, they are optional in the second year.

Judging from the poor priority accorded to this subject, science as a subject in the school curriculum is rated low by teachers and by the Ministries of Education. The needs identified in the various Country Papers presented

were as follows: (a) in-service teacher training; (b) provision of basic science equipment; (c) facilities for improvisation of basic science equipment; (d) provision of science rooms; (e) adequate reading material; (f) provision of science resource persons.

Secondary School Level

In most schools in all territories, science is taught as General Science, and separately as Physics, Biology, and Chemistry, mostly by specialist teachers in these areas.

At the junior secondary level, General Science is compulsory for all pupils, and currently West Indian Science curriculum materials are being used in a number of the schools in most territories.

At present most of the schools gear their senior high school programmes to the examination requirements of external examining bodies like Cambridge and London Universities. It is expected that pilot schools, selected from throughout the Caribbean, will take the Caribbean Examination in 1979, in the subject area of integrated science; the Caribbean Integrated Science Curriculum will be introduced into these pilot schools in the 1977/78 academic year.

In most schools, there is a heavy reliance on teacher demonstrations and chalk and talk exercises. Students have very little opportunity to handle equipment and to carry out practical work in science. By and large, this state of affairs was attributed to a number of reasons including the following:

(a) lack of sufficient equipment;

(b) shortage of adequately trained teachers;

(c) large class enrolments.

Participants highlighted a number of difficulties and problems they encountered in providing their schools with suitable science equipment.

The only choice that teachers have is to select materials that are listed, and sometimes briefly described, in foreign catalogues, usually of UK or US origin. A few schools use sources in Canada and Japan. In almost all cases, the equipment is ordered without prior experience of the suitability of the equipment for the local situation.

Apart from the fact that items are costly and foreign exchange is hard to come by, it was noted that the ordering of equipment for schools is generally beset by delays of up to two years in some cases. These delays tend to arise for a number of reasons, such as poor processing of orders by schools or purchasing agents, cumbersome procedure within the various government ministries involved in importing equipment, and the need in most cases, of having to order through the Crown Agents.

Furthermore, apart from these delays it was noted that rapid teacher turnover leads to ordering of equipment by teachers who leave before the order arrives.

Some participants thought that increasing the grants given to schools might help alleviate these difficulties. Others were of the opinion that a central purchasing unit ought to be set up within each country to handle bulk

orders despite the problems of organization, personnel, storage and distribution that this might pose.

Efforts of Countries in the Production of Low-Cost Equipment

At present no definite organized effort is being made in any of the countries to mass produce equipment for schools. None of the countries has, established units for producing locally-made science equipment to support local curricula, although improvization has been encouraged. Reasons given for this state of affairs includes the following: unavailability of competent teachers, the small school population in most territories, and the small margin of saving. Some attempts are now being made, however, by a few of the countries to produce prototype equipment such as test-tube racks, circuit boards, tripod stands and cell holders. These have generally been produced during teacher in-service training courses and, where they exist, by the Industrial Art Departments of some schools.

One thing that is greatly needed in the Caribbean is the development of equipment related to the curricula currently in use or in the process of being developed. Efforts in this direction, it was noted, ought to involve teachers in all stages of production. Since, in some cases, available equipment is either not used at all or used ineffectively, courses should be organized for teachers on the use of science teaching equipment.

THE POTENTIAL FOR
LOCAL MANUFACTURE OF SCHOOL SCIENCE EQUIPMENT
AND THE PROBLEMS OF EQUIPPING SCHOOL LABORATORIES

In the Caribbean, the traditional approach to science teaching - over-emphasis of teacher demonstration and learning by rote - is generally giving way to a new approach which involves inquiry, discovery, and the encouragement of pupil participation. The programmes being developed will therefore tend to depend heavily on an adequate supply of equipment and will become successful and effective only when the local resources are fully exploited and utilized.

The seminar looked into some issues highlighted in the lead paper based on Kenya's experience and which were also brought up in the country papers. It discussed the problems and difficulties which countries in the Caribbean face in equipping their school science laboratories, and explored the potential for local manufacture of science apparatus.

Improvization and Production

For many people, cheap apparatus is synonymous with improvization. No matter how well equipped a school science laboratory might be, teachers may sometimes find it necessary to improvize. Improvization should therefore be seen as something confined to the individual teacher: in other words, it should be viewed as an aspect of a teacher's training and his approach to work.

The meeting also pointed out that improvization should not be seen as being unrelated to mass production since, in many cases, it leads on to mass production. Thus, although the type of production with which the meeting concerned itself is not usually handled directly by teachers, teachers have a great contribution to make. This is because experience in many countries indicates that for a production unit to make the greatest educational impact, mass production of equipment must be carried out in such a way as to increase the involvement, confidence and skills of the average teacher. The teacher must be encouraged to view the production project personally if it is to meet with real success. As an example, the success of the development of the Science Equipment Production Unit (SEPU) biology kits in Kenya may be partly attributed to the fact that the consultant was a teacher with local experience and the majority of the members of the committee which decided on the original objectives were also teachers. Moreover, field trials, development of the accompanying teacher training programme, evaluation, and all aspects of production involved members of the teaching profession.

Present Source of Equipment and Evaluation

Though a certain amount of improvization, particularly by physics teachers, has added considerably to the range of apparatus available in some schools, schools are, in general, equipped with apparatus imported from the United States and the United Kingdom. A few countries also import equipment from Canada and Japan.

Participants expressed their opinions on the efficiency of individual suppliers. Some suppliers are more prompt and efficient in handling orders than others. United States and Canadian suppliers were more conveniently placed for certain territories, but their equipment did not always suit curricula based on United Kingdom sources such as Nuffield science and Scottish Integrated Science.

UNICEF provides equipment which is markedly less expensive than other sources, but its delivery period is often longer and more uncertain. Attention was drawn to the fact that it might be better, assuming there were no currency problems, to order direct through UNICEF's EVE catalogue.

Difficulties and Problems in Equipping School Science Laboratories

Economic, professional and educational issues were discussed. In view of the fact that almost all of the equipment used in Caribbean schools is imported, great concern was expressed about the long delays that occur between a school wanting the apparatus and actually getting it. Foreign exchange problems, import restrictions, and devaluation featured conspicuously when the causes of delay were reviewed.

Once the apparatus is in the school, other difficulties operate. Students, especially in the junior secondary schools, are usually weak in manipulative skills. This often results in a high rate of breakage.

Frequent staff transfers often mean that the teacher who originally ordered the item has left, and no one else seems to know what to do with certain items of equipment already available in the laboratory. The result is obvious - abuse and breakage, or an item left to gather dust on a shelf. Also, because of the fact that buying is, in some cases, done in very limited quantities by individual schools, there is lack of uniformity not only in the science apparatus found in different schools within a particular country but also within subject departments within a single school. This situation makes purchasing of spare parts, repairs and servicing difficult and expensive to undertake.

In discussing the above difficulties and problems, the opinion was expressed that it might make sound practical sense to co-ordinate all purchases of equipment through the activities of a central purchasing authority. In this case, it was thought that items could be evaluated by professional specialist staff and the most suitable items purchased in bulk and distributed.

There were reservations, however, to the establishment of such a central purchasing unit. Apart from political reasons, it was felt that a central unit would be beset by transportation difficulties. Also, such a system would have to contend with different systems of taxation and the effects of inflation and devaluation in currencies which are a feature of present systems of supply operating in the different territories. It was noted, nonetheless, that with the assistance of CARICOM, adequate legislation could be set up in each country to offset the taxation problem and thereby help cut down the cost of equipment.

At this stage the discussion revealed that there was need for clarification of the term "low-cost". The use of the term had given rise to confusion for a number of reasons. Some participants had identified the term "low-cost" with cheap sources of commercial or imported supply, and were consequently interested in finding out more about such sources of equipment. Others wanted to relate low-cost equipment to locally produced items but could not reconcile

d .s idea with the fact that those items, partly because they are mass produced for a low population target, sometimes cost more than imported ones. Again there was the misconception that production of science equipment entails the acquisition of expensive machinery. It was pointed out that this need not be so. Indeed, it has been shown by the SEPU and other experiences that many valuable items of equipment, especially those for primary school science, can be produced with inexpensive machinery.

Attention was drawn to the fact that the purpose of this seminar is to find ways and means by which Caribbean countries could produce suitable items of equipment cheaply. Admittedly the initial cost of locally produced items may sometimes be higher than that of imported ones, but it was pointed out that replacements and repairs would be facilitated and hence the equipment would be cheaper in the long run. In any case, it was generally agreed that it might be better to acquire something dearer if it is more relevant and more suited to the local curriculum, a condition which imported items, generally, are not able to satisfy because of the wide market for which they have been produced.

The concern over the establishment of centres for the production of low-cost equipment was so great that the meeting set up a Committee to: (a) examine and make recommendations on feasible ways of establishing local and/or regional systems of production based on criteria of cost, educational and national goals, and (b) prepare an outline of a project which could be submitted to an international funding agency.

After discussing the Committee's report, the meeting agreed that even though the idea of a regional production unit was a good one, it would at the moment be premature to recommend its establishment. However, it was recommended that local production units should be set up with a view to working towards the establishment of a regional unit later if feasible. It was agreed that a co-ordinating or monitoring unit should be established whose main functions would be:

(a) To collect, evaluate and distribute information on science teaching equipment.

(b) To advise and make recommendations on local production of science equipment.

(c) To encourage relevant local activity.

(d) To determine the feasibility of setting up regional, sub-regional or local production units.

It was also recommended that the Caribbean Regional Organization of Associations for Science Education be requested to perform the functions of the co-ordinating unit.

Existing Local Resources

Even though no organized effort is being made in any of the countries to produce equipment on a large scale for schools, it was noted that individual territories had already produced some prototypes. Participants mentioned the following prototypes as having been produced during in-service courses for teachers or by students in schools where industrial arts departments exist: circuit boards, spirit or kerosene oil lamps, mobile benches, trolleys, test tube racks, tripods, metre rulers, plastic lenses, resistors, laboratory

stools, exhibition tables, and wooden models. In addition to cost consideration, it was noted that in any local production enterprise the following factors should be borne in mind: the apparatus must be made to fit the curriculum; there must be uniformity in specifications of equipment produced; items of equipment produced must be accompanied by comprehensive instructional manuals; items of equipment produced must be robust, sturdy and durable.

The existing local resources in the Caribbean were grouped under four headings: Natural Resources, Energy Sources, Low-cost Labour, and Industrial Skills. The table shows that as a whole, the Caribbean has adequate local resources to make a production unit a viable concern. For instance, wood could be obtained in abundance in Guyana, Grenada, Dominica, Belize, St Vincent, and the Bahamas; labour is said to be cheap in Dominica; Trinidad, Guyana, and St Lucia could provide energy sources; there is adequate supply of water in Guyana and Dominica; mineral sources abound in Guyana, Trinidad, Jamaica, St Kitts, and St Lucia; and a lot of industrial skills are found in Trinidad, Dominica, Guyana, St Lucia, and Barbados.

Natural Resources			Energy Resources	Low-cost Labour	Industrial Skills
Wood	Water	Mineral			
Guyana Grenada Dominica Belize St Vincent Bahamas	Guyana Dominica	Guyana Trinidad Jamaica St Kitts St Lucia	Trinidad Guyana St Lucia	Dominica	Trinidad Dominica Guyana St Lucia Barbados

Contribution of Teachers, Technicians and the Community in the Production, Distribution and Evaluation of School Science Equipment

There was relatively little discussion on this section. Naturally, the role of teachers and technicians is a key one in any attempt to produce equipment at low cost, and the comments expressed in the lead paper were accepted without question.

Regarding the involvement of other personnel in the community, the youth camps found in Jamaica were cited as an example of possible sources of artisans that could be employed in a local enterprise. In this regard, reference was also made to the Guyanese system of community high schools whereby students attend school for two days of the week and work in factories for the remaining three working days. It was thought that this type of work experience could probably be channelled into the production of items of school equipment.

Experimental Units for the Production of Science Equipment at Various Levels

Whatever may be the nature and size of a unit for producing science equipment, factors such as time, money and siting need to be considered. Of these

constraints, the participants found it worthwhile to react to the issue of siting.

Considering the wide range of differences existing between territories in the region, participants thought it premature to discuss the establishment of a Caribbean-wide production unit. Consequently, participants decided to express their views in terms of individual territories or groups of territories, rather than of the Caribbean as an entity.

In this regard it was agreed that the development of experimental units in the various territories would depend on certain aspects of their educational and commercial practices. For instance, In Jamaica where many of the secondary schools with industrial arts departments run on a two-shift system, large scale production by these schools would not be feasible; improvization would be the only realistic thing to expect under the circumstances. On the other hand, participants from some of the countries represented - notably St Vincent and Trinidad - thought that their industrial arts centres and technical colleges could operate as production units.

Outside of normal institutions, the Youth Camps of Jamaica was noted as an organization that could undertake local production of equipment. No matter where the siting is, however, it was agreed that the success of the Unit would depend on good management and the application of hard-headed business methods which take into account the need for an extensive programme of evaluation and teacher training.

DESIGN, DEVELOPMENT AND PRODUCTION OF LOW-COST SCIENCE EQUIPMENT

The urgency of the need to develop low-cost science equipment for schools in the Caribbean was brought up during the presentation of country reports on the first day of the Seminar. This need was subsequently emphasized during the discussion of the lead paper on the potential for local manufacture of school science equipment and problems of equipping school laboratories. The general consensus of participants was that the development of equipment in each country should become an integral part of the local science curriculum.

During the discussion of the paper, attention was drawn to the need to generate ideas for the design of such equipment, to identify the role that relevant bodies could play in generating and making use of practical ideas, and to consider the function of production units in areas of design, production and evaluation of such equipment.

Production Unit

The issue of whether or not a centralized or decentralized unit should be set up within the Caribbean received much attention. Although the participants recognized that a centralized system would have such advantages as availability of resource materials and specialist skills, it was generally agreed that the difficulties involved in the mass production, distribution, communication and material resources could best be solved by decentralization. In this connection it was proposed that a survey of each territory should be conducted to determine how feasible it would be to set up such units within each territory. Meanwhile, however, the participants accepted the proposal that the first stage in setting up a production unit at the regional level should be the creation of a central monitoring body. One of the functions of this body should be to disseminate ideas on the design of equipment in the region.

Science Education Programmes

The country reports revelaed that in some countries science education was not receiving, either from teachers or from Ministry officials, the attention and consequently the place it deserved in the curriculum. Therefore, it was recommended that every effort should be made to convince governments about the need to accord high priority to science education at all levels, and to provide the time and money necessary for its development.

Also, in order to overcome the lack of adequate teacher training, which is one of the major obstacles to the introduction of science at the primary level, the following suggestions were made:

(a) Organization of seminars/workshops for interested participants.

(b) Demonstration and provision of materials, including specimen lessons.

(c) A salaried curriculum committee chairman to ensure continuity of curriculum development programmes.

(d) Consideration for adoption of the system in practice in some countries where the first week of the academic year is devoted to teacher seminars at which attendance is compulsory.

It was noted that a government body like the National Council of Educational Research and Training (NCERT) in India, assists in the development of meaningful programmes in many areas of difficulty, even before the design of equipment is attempted.

Areas of difficulty outlined by participants were: a curriculum that meets the needs of the schools; the motivation and training of teachers particularly at the primary level; development of instructional materials such as teachers' guides; and the provision of adequate laboratory/workshop facilities including trained technician staff.

It was also emphasized the money is an absolute factor in determining what a programme might be, and that proper costing therefore should be considered before ambitious schemes are attempted. Further, it was noted that the development of low-cost equipment should be seen as a necessary support to curriculum-based on pupil-oriented practical experience in science, and that the use of indigenous resources, including "scrap" material, would help to conserve much-needed foreign exchange.

Generation of Ideas for Equipment

Many of the countries represented at the seminar have science teachers' associations which are members of the Caribbean Regional Organization Assocation for Science Education (CROASE). It was recommended that where national science teachers' associations are presently non-existent, CROASE should encourage the formation of such organizations. It was also agreed that CROASE be requested to act as a clearing-house for teachers' ideas on designs, noting that teachers could generate ideas through activities such as science exhibitions and seminars/workshops similar to the current meeting.

A number of suggestions involved the use of students, at various levels, as a source of ideas. It was felt that technical students could concentrate on functional designs, while teachers in training colleges and undergraduates in university colleges should concentrate on methodology. Participants suggested that it would be useful to have a museum of scientific equipment and that regular exhibitions would be a stimulus to creativity in all sectors of the community, including technicians from schools, universities, industries, and other sections of government.

Also, exposure to existing pieces of apparatus and kits (such as those presented during the present seminar/workshop) could act as a stimulus to further ideas. In this regard it was recommended that a directory of commercial kits and literature about their use should be compiled for general information.

The Role of Relevant Bodies

Each of the territories represented at this meeting has some form of institution involved in curriculum development. This type of arrangement varies from informal activities of teachers to units within ministries of education or universities respectively. It was suggested that all efforts at producing ideas for

equipment design should be co-ordinated very closely with the curriculum development efforts of the various bodies, namely, science teachers' associations, university departments, educational research units, and the Caribbean Examinations Council. In particular, if countries plan to set up production units, national science research units should, where they exist, be asked to provide financial, technical and managerial assistance. Where these bodies do not exist, or where it is difficult to obtain assistance from such bodies, it was suggested that assistance should be sought from international or external donor agencies like UNESCO, UNICEF, the Commonwealth Secretariat, CIDA, and the British Council. In relation to funding by external agencies, attention was drawn to the Commonwealth Secretariat publication, International Activities in Science and Technology, which provides information on such donor bodies.

The meeting noted that the School of Education at the University of the West Indies, University of Guyana, and the Science Evaluation Unit of the Caribbean Examinations' Council could be sources of specialist advice in the field of production of equipment. It was felt that if territories kept them informed, their organs of communication could be used to disseminate information on areas of design, production and evaluation throughout the Caribbean.

In connection with evaluation of equipment, it was thought that when prototypes are available, items which lend themselves to production should be put into pilot schools as a kit. For effective pilot projects, it was suggested that in general, equipment should be tested in a wide range of school situations, and that the prototype builder should be involved in the testing exercise. Again, with regard to evaluation it was pointed out that difficulties relating to subjectivity in evaluation could be avoided or minimized by instituting cycle of work, with feedback at each stage. Evaluation could end with a conference of interested parties to review the programme.

THE ORGANIZATION AND MANAGEMENT OF

SCHOOL SCIENCE EQUIPMENT

This paper was originally prepared for and discussed, in broad terms, at the Commonwealth Conference on Materials for Learning and Teaching which was held in New Zealand in 1975.

At the seminar/workshop held in the Bahamas to deal specifically with science equipment, participants considered the possibility of establishing a Caribbean-wide production unit, and the place of resource centres in the Caribbean.

Caribbean-wide Production Unit

In the main, a Caribbean-wide production unit could be justified on the following grounds: saving of foreign exchange; the psychological satisfaction of being self-reliant; the social and economic advantage of using local labour especially in these days of unemployment; utilization of raw material resources of the region; assurance of the relevance and suitability of equipment produced for local curriculum programmes; ready availability of supply; and provision of a blue-print of a successful local proudction enterprise.

Nevertheless, attention was drawn to a number of factors that might militate against the immediate establishment of such a unit. Besides political considerations, economic and social difficulties included the limited market, currency differences, territorial tariffs, expensive regional freight services, intra-communication barriers, and inter-island rivalry.

The need for a special effort to minimize the negative effects of intra- and inter-territorial communication barriers was pointed out. Also noted was the fact that such a venture might become a success if the types of equipment produced could be limited to those for which the Caribbean possesses adequate technology.

Before such a production unit could merit the serious consideration of governments, however, it would be necessary to undertake feasibility studies on cost-effectiveness. It was suggested that such an exercise could be carried out by university personnel working under the direction of a CARICOM-appointed economist, or by experts from outside the region if necessary.

On the question of staffing of a possible production unit, it was agreed that the structure of the Science Curriculum Centre in Njala University College in Sierra Leone would offer a suitable one to follow. This consists of a general manager with overall administrative responsibility, a design and production manager, an educational consultant with responsibility for sales and storage, and a few technicians.

It was noted that the Caribbean itself could produce the staff required for the type of production unit envisaged. Thus, if and when the various territories decide to set up such a centre, the main training emphasis would be on familiarizing local staff with the specific techniques used in the production

of low-cost science equipment. In this regard, it would be necessary to provide new recruits with on the job training and/or to second them, on attachment courses, to existing production centres like Kenya's Science Equipment Production Unit and India's National Council of Educational Research and Training.

Such training efforts should be supplemented with technician training based on the SEPU-type of workshop experience, and sponsored by agencies like UNESCO, the Commonwealth Secretariat, and the British Council. The type of training suggested is one that might last for about six weeks and involve about 30 people in the management and repair of secondary school science equipment. Also, participants at this meeting should be people who, on going back to their own countries, could be used as resource persons in local seminars/workshops.

Resource Centres

Even though it was felt that the concept of a resource centre was not clearly understood in many countries, there was general agreement on the usefulness of such centres.

A resource centre was defined as a facility which produces and acquires suitable educational materials (e.g. textbooks, kits, films, slides, charts, etc.) and makes them available to teachers. Thus it services the needs of teachers and teacher educators, schools and colleges (including teachers and pupils), and the community at large. It was noted that at present the following countries have resource centres in various stages of development: Bahamas, Barbados, Belize, Bermuda, Guyana, Jamaica, St Lucia and Trinidad and Tobago.

In establishing such centres in the Caribbean, certain factors must be borne in mind. The centres should be tailored to meet the specific needs of the community they are designed to service, they would need to "sell" the concept of the resource centre to the public, and they may be sited to their advantage in the vicinity of or within existing educational institutions. Also, for proper administration, each of such centres should be made the full responsibility of one individual who should be assisted by a librarian and a secretary. The detailed staffing arrangements at such a centre would, however, depend on local circumstances and the stage of development of the resource centre.

THE USE OF LOW-COST SCIENCE EQUIPMENT IN SCHOOLS

Reference has already been made to the general trend in science teaching in the Caribbean - the development of programmes that rely heavily on adequate supply of equipment. Some of the items of equipment required are meant for teacher demonstration; for the student's handling and experimentation. However, very little seems to be known about what teachers actually do with the equipment they receive and how these items of equipment are stored and maintained.

Individual Student Experimentation versus Teacher Demonstration

It was generally agreed that both student experimentation and teacher demonstration are desirable and that in the classroom the proportion of time devoted to each is determined by a number of factors. These considerations include the availability of time and equipment, the aim of the experiment, the demands of the curriculum and the experience of the teacher. Of these, participants thought that the curriculum is the most important factor governing the choice of an experimental procedure, and that the other factors are likely to be adequately handled by the classroom teacher. The meeting therefore addressed itself next to methods by which schools could cut down costs.

It was suggested that the "station" or "circus" method of class experiments would reduce the number of items of equipment necessary and hence reduce costs. Further, the equipment for use by the student should, in general, be less sophisticated than that provided for the teacher. Apart from the fact that simple equipment is generally inexpensive, the use of such equipment tends to motivate the child to try to handle the apparatus.

Three categories of kits for students' use were recognized: those consisting of easily replaceable household items; those with components readily available in most laboratories; and specialized items (such as "quick-fit") that relate to specific areas of the curriculum. In practice the use of any of these types of kit imposes certain restrictions and difficulties. There is always the danger of losing essential items, particularly when they are small, and these are often difficult to replace. Even when spare parts are available, they may be difficult to fit unless adequate guides are available. Specialized kits are further handicapped by limited application.

Considering the total requirement for equipment in the Caribbean as a whole, participants agreed that the production of kits on a sub-regional or regional basis might be a viable proposition. Nonetheless, the earlier consensus that it would be premature to recommend the establishment of a regional production unit (page 11) was reaffirmed. Thus in line with the earlier decision, it was suggested that the needs and conditions in each country should be determined before a Caribbean-wide production programme could be structured.

Storage

Participants agreed that in the Caribbean the problem of storage of equipment is a major one. Various methods of dealing with this problem and the related

problem of safety of equipment in schools were discussed. These problems are considered especially acute in primary schools and in those secondary schools which have a science room rather than a fully furnished laboratory. It was felt, therefore, that the conditions prevailing in individual schools should govern the type of method selected. In general, the methods suggested ranged from pigeon-holed shelving to racks and compartmentalized boxes.

It was suggested that kits should be transported and stored in the same box so as to cut down losses and breakage. Boxes could be designed as cupboards for wall attachment if "dead space" exist in laboratories or science rooms. Mention was made of pilot schemes in Antigua where mobile storage benches have been made for use in primary schools at comparatively small costs.

The need to provide adequate bulk storage was also stressed and attention was drawn to instances where "uniport" materials have in the past been used to build storage rooms at reasonable costs. It was suggested that this type of construction could be investigated to assess its suitability and cost today, as one could easily be put up in a matter of days, using relatively unskilled labour.

Maintenance and Repair

It appears easier and cheaper to replace most pieces of damaged equipment rather than to repair them as only a few science kits have items that are amenable to simple repair work. Thus, apart from those items of equipment that can be recycled for use as substitutes, breakages generally tend to be discarded.

One way to overcome the maintenance and repair problems is to set up a maintenance centre in conjunction with a production unit so that complicated repairs can be undertaken. Another approach is to train teachers and students to do better than mere "hammer repairs". However, care should be taken to ensure that the burden of repairing equipment does not fall too heavily on the teacher or else it will cause further lessening of his motivation and thus drain his enthusiasm.

Much emphasis was placed on the urgent need to design and implement pre-service and in-service teacher training programmes in the use of equipment. These programmes should be designed to help improve the practical skills of teachers, and help them to distinguish between the jobs they can do themselves and those jobs that require an expert. As an example worthy of trial it was noted that in Guyana, science teachers are required to undergo in-service training in technical skills. In this Guyanese training scheme, "acting teachers" spend half their time in the classroom as teachers and half in workshops as technicians.

In view of the low standard and the rapid turnover of technicians currently available in the Caribbean, the Commonwealth Secretariat was asked to consider sponsoring a technician training course at the earliest opportunity. Participants emphasized that the course in mind is not the City and Guilds type which, according to many reports, appears to be unrelated to the present urgent needs of the Caribbean.

PROGRAMME OF TRAINING AND SUPERVISION FOR THE EFFICIENT USE OF SCHOOL SCIENCE EQUIPMENT AND THE DISSEMINATION OF INFORMATION RELATING TO THEIR USE

In discussing production of science equipment in the Caribbean a necessity which the meeting had earlier identified was to ensure that the equipment produced would be put to the best advantage. It had been suggested that there should be adequate teacher preparation, both at the pre-service and in-service levels, and that the teacher education programmes should include some training in the preparation and use of equipment. During the discussion of the lead paper on "Programme of Training and Supervision for the Efficient Use of School Science Equipment and the Dissemination of Information Relating to their Use", the meeting focused its attention on the development and establishment of in-service training centres at local, sub-regional and regional levels. It discussed the structure, organization, management and equipment of such centres.

Caribbean Regional In-Service Training Course for Science Teachers

The meeting agreed that like the proposal for a Caribbean-wide production unit, discussed earlier, the establishment of a Caribbean regional training centre should be looked upon as a long-term goal while, in the meantime, attempts are made to set up local training centres.

Local training centres should be established to undertake in-service training programmes for teachers and technicians in the use of school science equipment related to the local curriculum. Such bodies should also liaise with teacher training colleges, ministries of education, curriculum development centres, and resource centres, and organize workshops where prototype equipment could be developed and produced.

It was further suggested that if it was necessary to site a centre within an existing institution, care should be taken to ensure that its director and staff should be distinct from those of the host institution, although the staff of the latter could be expected to help when requested, with work of the training centre.

It was recognized that in some territories more than one centre would be required to ensure that teachers requiring training did not have to travel long distances. In such cases it was suggested that co-ordination would be done by the Ministry of Education, or the Science Teachers' Association where such a body existed. In any case, the Ministry of Education should be involved in work at training centres since it would ultimately be required to provide funds for their operation. Further, in order to ensure that the centres would be effective, the question of inter-territorial co-operation aimed at co-ordinating and monitoring their activities was raised. It was suggested that the Caribbean Regional Organization of Associations for Science Education, or another appropriate organization such as the Caribbean Regional Science Project, be requested to perform the functions of a regional monitoring body.

Teacher Centres

Because teacher centres have a very important role to play in improving the quality of teachers, many countries have already established such centres. Depending on size, need and means, a territory may decide to set up one centre or a number of centres. Where such teacher centres existed, the need for setting up special centres for science teachers would be obviated.

The meeting agreed that such centres should be set up in Commonwealth Caribbean countries. Accordingly, the Commonwealth Secretariat was requested to provide information about the equipment, organization and management of such centres.

Existing Media Facilities

It was generally agreed that the dissemination of knowledge about the use of educational materials was linked with teacher training in that any teachers who have undertaken a course are potential sources of information in their school and in the community as a whole. However, the meeting decided to explore other forms of disseminating information. Media facilities existing in the countries represented are radio, television stations, newspapers, information bulletins of science teachers' associations, government information services, and films.

The table on page 21 gives the position of such facilities in the countries represented at the Seminar/Workshop. It was suggested that governments should be encouraged to make more extensive and effective use of these facilities.

COMMONWEALTH CO-OPERATION IN THE MANUFACTURE, SUPPLY AND USE OF SCHOOL SCIENCE EQUIPMENT

One of the functions of the Commonwealth Secretariat is to encourage and promote co-operation among member countries in the field of education. Four main ways in which this is done are: organizing conferences, seminars and workshops; carrying out research; collecting and disseminating information; and organizing and supporting training courses.

It was pointed out that in performing its tasks the Commonwealth Secretariat works closely with international agencies like UNESCO and the World Confederation of Organizations of the Teaching Profession (WCOTP), regional organizations like CARICOM, and national organizations like the British Council, thus avoiding unnecessary duplication of effort. Also, the Commonwealth Secretariat tries to keep in touch with teachers' organizations and professional teachers' associations, particularly in their task of fostering educational development not only on a national basis but also among Commonwealth countries.

The meeting discussed recent and current activities in the educational programme of the Commonwealth Secretariat. It noted that the recent publication, The Production of School Science Equipment: A Review of Developments has been well received by member countries. Participants were informed that a follow-up booklet which looks at four different approaches to the solution of the equipment problem would shortly be published. Though participants showed appreciation for the information on the publishing role of the Secretariat, many of them complained that generally the publications do not reach them.

Participants showed keen interest also in the following opportunities for Commonwealth Secretariat help: bursaries for trainee technicians at production centres already in existence in the Commonwealth; travel grants for persons working in science education centres and who have interest in design, production, distribution and use of low-cost science equipment; fellowships for teachers to undertake postgraduate studies in science education.

The discussions led to a number of requests in which the Commonwealth Secretariat was asked to:

(a) Circulate information on developments in the field of school science equipment.

(b) Compile a directory of commercial kits and literature about their use.

(c) Encourage the free flow of samples of low-cost science equipment among Commonwealth countries.

(d) Investigate the design of basic equipment which can be used widely, especially where there is no supply of electricity.

(e) Encourage regional co-operation through standardization, production and distribution of locally-produced science equipment.

(f) Assist with programmes of in-service training of teachers and with the running of national or regional science workshops.

(g) Organize, at the earliest opportunity, a Commonwealth conference on school science teaching. Possible themes suggested for the specialist conference were "How Science and Mathematics Teaching can be Co-ordinated at the School Level", and "Communication in Science Education".

Participants also asked the Commonwealth Secretariat to review its system of disseminating information, to ensure that it got into the hands of those who needed it. Participants would like the Commonwealth Secretariat to provide information on:

(a) Setting up and running resource centres;

(b) Commonwealth countries; up-to-date facts in as many fields as possible e.g. history, politics, culture and economics.

Many participants expressed appreciation of the work of the Commonwealth Secretariat. The meeting hoped the Commonwealth Secretariat would assist territories, as much as possible in implementing projects that might result from the present Seminar/Workshop.

SUMMARY OF LABORATORY EXERCISES

The whole range of kits produced by the Kenya Science Equipment Production Unit (SEPU) was displayed together with a small number of items from the science kits of the National Council of Educational Research and Training (NCERT) of India. The kits from both countries were accompanied by manuals for students and teachers. A few experiments were set up using these kits. Participants were encouraged to try to use the equipment in much the same way that a student might.

Discussions

In assessing how students in the Caribbean might cope with the kits and the accompanying manuals, participants were guided by the following questions:

(a) How well could school children in the 11-14-year age range assemble the apparatus?

(b) How appropriate would the manuals be for students and teachers of the 11-14-year-olds?

(c) Could the kits and manuals be adopted in the Caribbean?

The discussions revealed that the kits have much relevance to the educational scene of the Caribbean. Facilities for teaching and learning bear much resemblance to the situations for which the SEPU and NCERT kits were produced. With little modification the kits would be suitable for upper classes in all-age schools and in junior (lower) secondary schools. Participants thought many of the secondary schools are, at present, fairly well equipped for their present purposes. However, even at this level of education, the flexibility of the multi-purpose components of the SEPU and NCERT kits would enable them to be modified to serve a useful purpose in the Caribbean.

Practical Work

Because participants realized that the greatest need for equipment was at the primary and junior (lower) secondary schools, they decided to design equipment for teaching at those levels using SEPU and NCERT ideas for the purpose. One group focused attention on lower primary school work; three dealt with upper primary school work; and three more initiated projects for the junior (lower) secondary school level. All groups had access to the pupils' and teachers' manuals of the West Indian Science Curriculum.

The lower primary school group produced a kit designed to illustrate sound and the effects of sound. The main component of the apparatus was a multi-purpose wooden box suited to machine production.

For the upper primary level, one of the three groups produced a kit tha. could be used to teach the topic "pressure". Using easily obtainable materials, the group made items which could be used in a number of different activities to explain the concept of pressure. A second group developed a project on solar energy, and a third constructed simple items of equipment that could be used to teach the topic "friction".

One of the groups interested in junior (lower) secondary school work constructed a simple viewer, and used it to observe plant and animal cells. This group also produced teachers' guide, pupils' worksheet, and instructions on care and handling of the viewer. The two remaining groups worked with circuit boards: one made the base out of pegboard, and the other out of strips of wood.

For each of the projects mentioned above, participants were encouraged to write down the difficulties they encountered in producing the equipment and to note what efforts they made to overcome the difficulties. Projects started but found not feasible were also noted, and reasons given as to why they could not be carried out. Efforts were also made to develop manuals which would serve as guides to teachers as well as students.

THE POTENTIAL FOR LOCAL MANUFACTURE OF SCHOOL SCIENCE EQUIPMENT AND RELATED PROBLEMS

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The last ten years have seen dramatic changes in education in most Commonwealth countries. "Universal Education" has become a political catch-phrase, and the number of schools and colleges has increased enormously in a brave attempt to match this ideal. Africa has been quick to adapt to recent changes in science curricula. In common with world trends, syllabus development has been accompanied by a search for more effective means of teaching, with stress being placed on the learning of practical skills and on promoting a general understanding of the methods and processes of science. Changes such as these impose on the education system considerable demands for science equipment that can be met successfully through production at the local level.

In attempting to survey a field of this scale in relatively few words, there exists a danger of being trite. Because of this, the approach adopted here has been to rely extensively on material and experience gained in Kenya as a basis for discussion. While the diversity of countries and cultures represented at this workshop makes generalization difficult, it should nevertheless be possible to identify a number of situations and problems we have in common.

A further point must be made here. Until comparatively recently, cheap apparatus has been synonymous with improvisation. In this paper where our main concern is local manufacture (i.e. large scale production at the local level), improvisation is seen as something confined to the individual teacher; it is part of his training and approach. Moreover there is always room for improvisation, no matter how well-equipped a school science laboratory may be.

Present Source of Equipment

The present supply situation in Kenya is probably typical of most Commonwealth developing countries. The 1,250 or so secondary schools purchase the bulk of their equipment direct from commercial suppliers operating mainly in Nairobi, the capital city. These firms import directly from overseas, with the bulk of their supplies coming from Western Europe, the United Kingdom and the United States of America. Of late, however, there has been a welcome departure from this pattern in that cheaper materials - from India, Pakistan and Japan, in particular - are becoming increasingly available. Very little effort has been made to harness the support of local manufacturing industries, and although it is possible to buy locally made test-tube racks for example, prices are not competitive and the standard of production is very low.

A certain amount of improvisation, particularly by physics teachers, has added considerably to the range of apparatus available in a few schools. Regrettably, good ideas are rarely passed on, and seem to be the prerogative of those schools and departments with experienced expatriate staff. Also, in

the last few years the Nairobi-based School Equipment Production Unit (SEPU) has been making successful attempts to meet increasing demands for equipment for both rich and poor schools.

Difficulties and Problems with Equipping Schools with Suitable Equipment

Very little has been attempted in the way of formal evaluation of science equipment in Kenyan schools, but the writer believes such evaluation is not necessary in order to review some of the difficulties and problems that are discussed below.

(a) Economic: Foreign exchange problems, import restriction and devaluation are important economic circumstances that cause difficulty or delay in getting equipment. Apart from those items that can be obtained fairly readily from the very limited basic stock maintained by most suppliers, it takes from three to eighteen months for orders from abroad to arrive in a school. With rising inflation, the longer the delay, the higher the prices schools have to pay.

(b) Professional: With an irregular supply of apparatus, it would make sound practical sense to co-ordinate all purchases of science equipment through the activities of a central purchasing authority. Specifications could be examined, and the most suitable items purchased in bulk. Unfortunately there are many drawbacks to such a system. Apart from political considerations, it is obvious that for a central authority to be successful and effective, it would have to be well staffed with teachers experienced in local conditions. Many developing countries in the Commonwealth cannot afford the cost of setting up such a body. Thus in Kenya and other countries known to the writer, buying of equipment is the responsibility of individual science teachers or, more often, of purse-holding headmasters who lack specialist science training.

Once the apparatus is in the school, additional difficulties arise. Frequent staff transfers often mean that the teacher who originally ordered the item has left. No one else seems to know what to do and the result is either an item being left to gather dust on a shelf, or abuse and breakage. Such events as using an AC power supply unit for electrolysis, and burning out sensitive meters and damaging the objective lenses of microscopes, may seem petty in this context but they are very real and important problems in any consideration of local production of low-cost equipment.

(c) Uniformity: Because of this buying in very limited quantities by individual teachers, there is a lack of uniformity not only in the science apparatus in different schools, but also among subject departments within a single school. The resulting hotch-potch renders the purchasing of spare parts and routine maintenance difficult and expensive.

(d) Educational: Junior students in secondary schools are usually weak in manipulative skills. Their home background is generally such that it would be unreasonable to expect otherwise. Unfortunately, because of a general lack of confidence on the part of science teachers, very little is done to correct this: the amount of practical work contained in typical science lessons is minimal and so a weakness extends right through the secondary school course. This situation results in a

high rate of breakage. So, in equipping schools with suitable equipment, robustness and durability are characteristics that must be taken into consideration.

One of the important principles put forward by the recent Commonwealth Conference on "Materials for Learning and Teaching" held in New Zealand was that learning materials intended for school use should evolve from the requirements of the curriculum rather than from available hardware or software. The present workshop provides us with an excellent opportunity to stress this idea. If apparatus is being designed and manufactured locally, we should make sure that it fits in with the educational requirements of a particular situation. It is all too easy to build a piece of apparatus without first taking a long hard look at educational objectives.

Summarizing the above problems one would say that in attempting local manufacture of equipment, the following points must be borne in mind:

(a) What we produce must be cheaper than that available through a commercial supplier; this entails a careful consideration of <u>all</u> the costs involved in producing a given item.

(b) Items must be robust and sturdy, but at the same time appearance must not be overlooked.

(c) Instructions must be produced which are fully comprehensive: they must include instructions on how teachers should use the item to make their lessons and schemes of work achieve intended objectives.

(d) Uniformity is important so that replacement and repair are facilitated.

(e) We must never lose sight of educational objectives. It is very easy in the workshop to get carried away with the idea that just because a thing <u>can</u> be done it <u>must</u> be done.

These principles, although they seem very obvious when written down in this way, have been learnt through experience. SEPU has a considerable number of pieces of apparatus which have "gone wrong" because one or other of these principles has been ignored.

<u>Existing Local Resources - Types of Science Equipment that can be Produced Locally and Cheaply</u>

Having outlined the problems of supplying school equipment, we are in a better position to look at possible solutions. But rather than philosophize over what <u>could</u> be done, it might be more profitable to examine closely what <u>has</u> been <u>done</u> in one particular case. The remainder of this paper deals with the current work of the School Equipment Production Unit in Nairobi.

SEPU has been in existence for nearly ten years. Its present form, however, is the result of a process of gradual evolution. Mistakes have been made in the past, and the present structure of SEPU reflects them. The unit is now organized as a private company backed by Swedish aid money and personnel. Over the next five years this aid will be progressively reduced so that by 1980 it is hoped that Kenya will be left with a fully viable and self-supporting unit.

At present the development of items of equipment is in the hands of expa iate staff, while the actual production is carried out by locally employed, unskilled workers. A Swedish design technician produces hand-operated tools for the production of most pieces of apparatus. In this way, SEPU is able to combine labour intensive methods with simple production techniques to produce low-cost apparatus at labour costs of about K.Sh. 12 (US $1.4) per hour.

Currently three types of kit (for physics, chemistry and biology) are being produced by SEPU, and monthly sales have now reached the K.Sh. 60,000 level (approx. US $7,5000). In each case, SEPU's approach has been to produce a nucleus of apparatus that can be used to carry out an adequate range of experimental work up to the East African Certificate of Education level. Each kit includes instruction manuals for students and teachers.

Despite the limited methods of production, SEPU has met with considerable success. Items like hand lenses and variable resistors which SEPU used to import for distribution are now being produced locally with the aid of machinery no more complicated than a lathe. All the same it must be pointed out that SEPU continues to make use of bulk purchases of glassware and thermometers from foreign suppliers for inclusion in its kits.

The success of the SEPU science kits should be measured in the light of the difficulties that have already been mentioned. Firstly, local production and bulk purchase reduce costs considerably and, more important, the apparatus going into the schools is suited for its purpose. Secondly, instruction manuals provide the step-by-step help which inexperienced teachers require. Thirdly, each kit is designed for group work rather than for teacher demonstration, and it is hoped that the setting up of the apparatus will lead to an improvement in manual skills. Lastly, these three kits very definitely fit in with current syllabus requirements.

Besides centring the work of the production unit on the science kit, SEPU has been involved in the production of other items. Slide sets on local applications of science, and standard items like dynamics trolleys, ticker timers, meter 'ridges have all been produced in the workshops.

Contribution of Teachers, Technicians and the Community in the Production, Distribution and Evaluation of School Science Equipment

The successful development of an item of science equipment or of a kit depends upon many variables, and the contributions of educational personnel vary from project to project. The flow chart shown in figure 1 is a summary of the development of the SEPU biology kit for which the author of this paper was the consultant.

A diagram of this sort can be misleading in that it presents development as a series of discrete stages: objectives are defined, materials developed, field trials follow, and so forth. In reality there is considerable overlap, and it is quite usual to find that certain items are on field trial while others are in the developmental stage.

In order to make the greatest educational impact, a major project like this must increase the involvement, confidence and skills of average teachers. They must be encouraged to view the project personally; for only then will it meet with real success. This involvement is illustrated in the flow chart. Every box in the figure with the exception of that dealing with actual production of materials, contains the word "teachers". Teachers formed the core of the committee that decided the original objectives; the consultant was a member of

that committee and was seconded from the Ministry of Education to SEPU for the purpose of developing the biology kit. The field trials, the development of the accompanying teacher training programme, the evaluation, and all aspects of production required the involvement of the teaching profession.

The question of relevance to the local situation should be high on any list of educational objectives, and it is here that the role of the community is important. It is a rich source of useful material and, with the aid of personal contact, its potential can and should be exploited to the full at the developmental stage.

The other critical component of the development team is the technician. His is often a sobering influence. He talks in terms of money, time and feasibility, and is responsible for translating teachers' flights of fancy into concrete practical terms. The diagram suggests that he is concerned in relatively few stages of the development, but he should, in fact, show an interest in all stages including such areas as sales and teacher training.

Setting up Experimental Units for the Production of Science Equipment at various Levels

Whatever the size and nature of a unit for producing science equipment, two things come immediately to mind - time and money. Anyone experienced in the production of scientific materials will appreciate that the total time involved is considerable. For example, the Nuffield Foundation's "Resources for Learning Project" showed that 22 man-hours were necessary to produce a single hour of student material!

No developmental project is free from political influence, and in many developing countries political pressures can be high. Results are required, often urgently. Time is obviously at a premium. An examination of the apportionment of time in the development of the SEPU biology kit as shown in figure 2 reveals that only about 60% of the available time is spent on development itself. The remaining 40% is necessary to carry out field trials, evaluation and teacher training. Clearly, if pressures are high enough, this is where the cutting will take place, despite the enormous value of these aspects to production.

The diagram representing the allocation of money makes no attempt to discuss the total amount involved. Two basic considerations have been omitted entirely: salaries of staff (other than those of unskilled workers), and the initial cost of establishing the unit.

In addition to time and money, the siting of a unit is a factor that needs to be considered. Various possibilities are reviewed below:

(a) Schools: Students and teachers in Kenya are under considerable stress brought about by syllabus requirements and the spectre of examination. Bearing in mind what has been said about time, it will be apparent that only small-scale production and improvisation are feasible at this level. It is unrealistic to expect anything else.

(b) Technical Colleges: In terms of facilities, technical colleges offer rather more than schools, but the same pressures apply. SEPU was originally planned as a part of the Kenya Science Teachers' College. While it was appreciated that much could be gained from close association of the two, it soon became apparent that staff and workshops had to separate.

(c) Village or City: For political reasons there is much to be said for the establishment of production units as rural industries. In practice, certainly in Kenya, the resulting problems would be insuperable, coverning such features as provision of electricity, close proximity to other supply firms, and communication with teachers. (A teacher visiting a city is quite likely to pay a casual visit to the production unit: it is unlikely he will travel out to a rural area to do this.) Whether the production unit is sited in a village or city, it must be organized on an industrial scale. Its success will depend on good management and the application of hard-headed business methods will take into account the need for an extensive programme of evaluation and teacher training.

THE DEVELOPMENT OF THE SEPU BIOLOGY KIT

FIGURE 2. THE DEVELOPMENT OF THE SEPU BIOLOGY KIT
APPORTIONMENT OF TIME AND MONEY

DESIGN, DEVELOPMENT AND PRODUCTION OF LOW-COST SCIENCE EQUIPMENT

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Science Education Programme

In general, the objectives of a science education programme of a developing country may include the following:

(a) Curriculum development, including the pilot stage of testing methods and materials.

(b) Organization and development of pre-service training of prospective science teachers.

(c) Organization of regular in-service courses, including enrichment programmes, to equip teachers for the new science curriculum.

(d) Development of instructional materials such as textbooks, teachers guides, science and other equipment.

(e) Provision of laboratory/workshop facilities in teacher training institutions.

In India, education is a State subject, and the Central Government is mainly responsible for laying down broad policies for concurrence by the States and ensuring co-ordination of the various activities. The Central Government supports experimental projects academically and financially, and also functions as a monitoring agency for the programmes of external assistance in the States. The National Council of Educational Research and Training (NCERT) is the academic agency of the Central Ministry of Education for bringing about improvements in all aspects of school education.

This paper sets out what is, by and large, the Indian experience in the design, development and production of low-cost science equipment. Some aspects of it would be of relevance to many developing sister countries faced with the problem of equipping their schools and teacher training institutions.

The science education programme in India has been in existence for over a decade. It was primarily undertaken to support a curriculum development programme of teaching science through practical activities and real experiences. A strategy had to be adopted whereby simple equipment made from indigenous materials and using local resources could be made available to the teacher in the classroom. Incidentally, the development of such science equipment in the form of compact, portable laboratories or kits also helped to conserve much-needed foreign exchange.

Curriculum and Ideas for Design of Equipment

While the broad outlines of objectives and curricula for school education are formulated at the national level, the actual details are drawn up by State Education Departments and State Boards of Education. The expertise of universities and research institutions throughout the country is utilized in developing model curricula for schools. The draft curricula, the syllabuses, and instructional materials with innovative ideas responsive to national needs, are made available to the States for trial and adoption or adaptation according to the local needs and resources. Thus the whole curriculum development process initiated at the Centre becomes a decentralized activity at the State level through a network of curriculum development centres.

At the State level, a number of agencies become directly or indirectly concerned with the curriculum. The State Institutes of Education, State Institutes of Science Education, Boards of Secondary Education, the Textbook Bureaux, Guidance Bureaux and other similar specialized institutions are also involved in curriculum work in some form or the other. The NCERT co-ordinates the work of these bodies.

In science subjects, experts of the curriculum body spell out the specific experiments or the purposes of the design, and identify the type of supporting equipment required. In addition, they scrutinize some of the conventional equipment readily available in the market and report on their merits and shortcomings. With this information at his disposal the designer makes a prototype. This prototype is then reviewed in advisory committee meetings comprising interested teachers, eminent scientists and staff of the design centre. At these meetings the product is thoroughly examined and suggestions are made to help improve the design.

At the design stage it has been found useful to involve teachers who are the actual users of the equipment. Encouragement for their participation is effected through design competitions and appeals to teachers through different science teachers' association, regional science officers, teachers' centres etc. Professional designers of science equipment have also been invited to participate. In addition, resource materials from international agencies have proved very useful.

Types of Low-Cost Equipment

Depending upon the requirements of the science education programme, the designer may start designing one or more of the following:

(a) A pack of equipment, for demonstration or pupils' activities, based on the curriculum for a particular class.

(b) Inexpensive substitutes for conventional laboratory equipment.

(c) Equipment needed for use at science centres and science fairs. (Though these items are not covered by the curriculum, they do have a unifying effect across the arts and science disciplines of the curriculum, and also tend to promote public understanding of materials and practical techniques.)

The pack of equipment in (a) above, may be a kit for teaching electricity to the students of Class VIII or a primary science kit for teaching science to the students of Class III. In all cases, the designer has to grasp the spirit of the particular curriculum, try to follow the textbook sequences

and illustrations, and model his design in such a way that the same equipment could be modified for use in different classes. The pack of equipment for a particular class level ought to be portable, act as a mini-laboratory suitable for use even in rural schools where laboratories for science teaching are non-existent. The cost of equipment may be reduced to the minimum, utilizing most of the items which are readily available in the local market. Items need to be sturdy in construction and simple in operation so that the children can use them without any fear of damage. The NCERT kits produced are designed to provide the following advantages: compactness; multi-purpose use of items; economy of time in setting up experiments; economy of consumable materials; portability; provision for teacher's innovation; low-cost and use of indigenous resource materials; and easy replacement of lost or broken items.

An essential component of a kit is a guide containing a list of items with sketches, detailed descriptions and instructions on how to use each item. This facilitates not only the proper use of the kit but also helps replacement of any part rendered unserviceable.

Production

Once the design has been worked out, the design office makes the drawing of the approved model with complete technical specifications. The drawings are then passed on to the production section for batch/mass production through the production-planning and control section. The various functions of the Centre producing low-cost science equipment are as suggested in the diagram. With expert advice from the Centre, the States draw up their plans and arrange for the necessary funds to meet the equipment needs of schools over a specified period. A region which does not have any local industries may prefer to request the Centre to undertake the mass-production for them, whereas a region located in the industrial belt may prefer to get the equipment manufactured locally with or without modifications as shown by the dotted lines in the diagram on page 36. The Centre can provide the design specification and necessary information for them. In addition, the State may ask the Centre to train their technical staff in the inspection and quality control aspect of equipment production.

Though the science kits have been very effective in implementing the science education programme, mass-producing and supplying them pose many problems, particularly in a large country like India. For instance, a State with 30,000 primary science schools distributing at the modest rate of 2,000 primary science kits per year, will need 15 years to cover its entire school population. By this time, not only would the population of the State have increased considerably but also the content of science would have altered completely. As the State cannot wait so long to see all the schools with a kit, it should encourage the use of local resources for the practical aspects of science teaching. Using illustrated pamphlets and booklets published by the design centres, teachers can fabricate educationally-useful equipment out of locally-available materials. If need be, they will seek the help of local craftsmen. Excellent innovative teaching aids may be made out of scrap materials like used razors, used plastic and tin containers, used bulbs, aluminium foils in cigarette packets, steel straps or packing boxes, other day-to-day household goods, and common materials like wood, bamboo (which may be used as rigid pipes, cylinders, measuring vessels, syringes, and frames for structures), the hollow stalks of some leaves and flowers (for making flexible pipe), hard thorns, different types of fruits, clay, straws. All these are available even in the remotest villages.

SUGGESTED ACTIVITIES OF THE DESIGN, PRODUCTION AND EVALUATION CENTRE AT THE NATIONAL LEVEL

ANNEX

BASIC EQUIPMENT FOR A LOW-COST SCIENCE EQUIPMENT PRODUCTION CENTRE

For design and development activities combined with an average production worth £100,000 (on no profit, no loss basis), a modest requirement of equipment is given below for a workshop having nearly 2,000 sq. metres of covered area and employing nearly 100 persons. The list may prove uneconomical for small countries. In such cases neighbouring countries may decide to establish a common regional centre to cater for their needs.

A. Design Section

1. Drafting machine, drawing board, instrument box, set squares etc.
2. Ammonia printing equipment.
3. Electronic stencil cutter.
4. Duplicating machine.
5. Screen printing equipment.

B. Development Section

1.	Tool room lathe	- Height of centre - 150 mm distance between centres - 500 mm
2.	Precision lathe	- Height of centre - 100 mm distance between centres - 300 mm
3.	Screw cutting lathe	- Height of centre - 200 mm distance between centres - 1 metre
4.	Drilling machine	- Capacity - 18 mm Height of work - 200 mm
5.	Padestal tool grinder	- Wheel dia - 400 mm
6.	All types of handtools for fitting jobs	

C. Machine Shop

1.	Screw cutting lathe	- Height of centre - 200 mm distance between centres - 1000 mm
2.	Screw cutting lathe	- Height of centre - 200 mm distance between centres - 1 metre
3.	Precision lathe	- Height of centre - 200 mm distance between centres - 1.5 metre
4.	Screw cutting lathe	- Height of centre - 175 mm distance between centres - 1.2 metre
5.	Shaping machine	- Stroke - 600 mm
6.	Padestal tool grinder	- Wheel dia - 400 mm - 3 Nos.
7.	Power hacksaw	- Max. dia of work - 150 mm
8.	Universal milling machine	- Vertical travel - 300 mm Horizontal travel - 320 mm Cross travel - 200 mm
9.	Vertical milling machine	- Swivel head, travel of head - 200 mm Vertical travel of bed - 300 mm
10.	Horizontal milling machine	- Vertical travel - 800 mm Horizontal travel - 800 mm Cross travel - 500 mm

11.	Universal tool & cutter grinder	-	Longitudinal traverse - 400 mm Cross traverse - 150 mm Vertical movement of wheel head - 100 mm
12.	Cylindrical grinder	-	Max. work diameter - 150 mm
13.	Surface grinder	-	Table travel - 710 mm Vertical travel - 300 mm Cross travel - 235 mm
14.	Engraving machine	-	Horizontal travel - 200 mm Vertical travel - 300 mm Cross travel - 200 mm
15.	Turret lathe	-	Bar capacity in collet - 18 mm
16.	Semi-automatic capstan lathe	-	Bar capacity in collet - 18 mm Bar capacity in chuck - 50 mm
17.	Pillar drilling machine	-	Capacity - 25 mm
18.	Bench drilling machine	-	Capacity - 12 mm
19.	Spring winder		
D.	<u>Die Stamping Section</u>		
1.	Punch press	-	Capacity - 40 ton
2.	Hydraulic press	-	Pressure - 400 kg./cm^2
3.	Lathe (gap bed)	-	Height of centre - 200 mm distance between centres - 1 metre
4.	Fly press, hand-operated	-	No.4 and No. 6
E.	<u>Sheet Metal & Fitting Section</u>		
1.	Power-operated sheet cutting machine (guillotine shear)	-	Length of cut - 2 metres Max. thickness of sheet - 3 mm
2.	Power-operated sheet bending machine	-	Length of bed - 2 metres Max. thickness of sheet - 3 mm
3.	Hand-operated shear	-	Max.thickness of sheet - 16 SWG
4.	Drilling machine	-	Capacity - 12 mm
5.	All sheet-metal and fitting hand-tools		
F.	<u>Carpentry Section</u>		
1.	Wood turning lathe	-	Height of centre - 100 mm distance between centres - 1.2 metre
2.	Thickness planer	-	Max. thickness of work - 150 mm
3.	Foot-operated fretsaw		
4.	Band saw		
5.	Circular saw	-	Diameter - 400 mm
6.	Disc and belt sander	-	300 mm disc
7.	All carpentry hand-tools		
G.	<u>Plastic Moulding Section</u>		
1.	Plastic injection moulding machine (manual)	-	200 gms. capacity
2.	Plastic injection moulding machine (manual)	-	60 gms. capacity
3.	Plastic injection moulding machine (semi-automatic)	-	100 gms. capacity

4.	Plastic injection moulding machine (manual)	-	30 gms. capacity
5.	Blowing-moulding machine (manual)	-	100 gms. capacity
6.	Blowing-moulding machine (manual)	-	30 gms. capacity
7.	Plastic scrap cutting machine	-	
8.	Vacuum forming machine	-	450 x 450 x 200 mm capacity
9.	Plastic coating equipment		
H.	Optics Section		
1.	Glass blowing equipment	-	Set of glass blower tools - 2 sets Blast burner - 2 Nos. Small air blower with air flow and pressure valve - 1 No.
2.	Lens grinding machine		
3.	Polishing machine		
I.	Electro-plating Section		
1.	Rectifier/motor generator		
2.	Tanks, salt accessories		
3.	Polishing machine		
J.	Welding Section		
1.	Gas welding equipment		
2.	Arc welding equipment (transformer, electrodes etc.)		
3.	Spot welding machine	-	Max. sheet thickness - 18 SWG
K.	Foundry		
1.	Blower and pit furnace for floor moulding		
2.	Crucibles and all foundry tools		
3.	Die casting machine (medium)		
L.	Painting Section		
1.	Spray gun		
2.	Air compressor		
M.	Electrical Section		
1.	Coil winding machine		
2.	Multi-meter and other metres		
3.	All hand tools for electrician		

N. General

1. Measuring tools
2. Inspection tools and gauges
3. Cutting tools
4. Portable drilling machine with accessories for converting it into other powered tools
5. Conveyor belt for inspection and assembly purposes
6. Sundries

THE ORGANIZATION AND MANAGEMENT OF EDUCATIONAL MATERIALS

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Education and Social Change

A great deal of thought is being given all over the world to the question of education being an agent for accelerating economic, social and cultural change. If things are allowed to drift and take their own course, the rate of growth of the economy and the associated facets of culture and education is bound to be slow. The imbalances and maldistributions which exist in the developing countries in particular cannot be overcome rapidly, while their existence for any length of time creates social and political problems. The state of the world, and man's knowledge of it, are such that people compare their conditions with those of other sectors of society and other countries, and they place high expectations for transformation of their lives with their country's leaders. It is in this context that education has to play a positive role as an instrument of development and change.

It is again in this very context that objectives of education are established by any government in any country. These objectives are specific to the history and current needs of the situation in any given country. Therefore, no country can really provide a model for a ready-made answer for another; but each can certainly learn creatively from the experience of the others.

Social objectives and, in turn, educational objectives determine to a large extent the nature and pattern of the organization and management of educational materials; so also does the choice of materials from the large variety that is available.

Special Problems Arising from Social Purpose and Conditions

In India, after Independence, popular expectations have been roused to an immense degree since equality of opportunity is the demand of every section of a democratic and free society. Each section knows that a great many opportunities in life are connected with the various levels of education and training. Hence, there has been a great demand for all levels of education. Equality of opportunity for the individual and, in fact, rapid economic development in the society are connected with universalization of elementary education. We have found that the deprived sections of the society cannot afford to send their children to whole-time schools for given periods of time in a year and for a span of several years. The children are a source of some financial or service benefit to the family, and the poor cannot afford to give up this advantage. This obliges us to think of various patterns of non-formal education departing in content and in institutional structure from formal education. The implications of this approach for the organization and development of materials are immense.

An important educational fact is that children learn a great deal within their families in the pre-school stage. We cannot intervene to give a better quality of learning to this stage of experience without the education of parents and a change in living conditions. Even if we leave this immense task to be taken up separately, it is a fact that the child learns far more efficiently in the school if he is taught in the mother tongue. Now in a vast country like India this involves the production of educational material in a large number of languages. Even the constitutionally-recognized major languages are fifteen in number. For historical reasons in our country, education is a State subject which means that the content and organization of education is the business of the various States. This again is connected with the question of a large number of languages in which material has to be produced and makes the problem specially complicated.

Our educationists have come to the conclusion that in order to save education from becoming bookish, it has to be based on the environmental approach. In the very first few classes at school we need not differentiate between science and social science because a child's experience is not boxed in such categories. On the other hand if environmental situations are to be a source of learning, then we cannot have a fixed and set pattern for the whole country. We can give guidelines; we can prepare teachers; but a great deal of initiative has to be left to the teachers and managers of schools, and obviously this complicates the situation with respect to the organization and management of educational materials.

Our social system which has given rise to our expectations and aspirations also demands that education is not to be neutral with respect to values. We cherish social justice, socialism and secularism; and while we have a multi-cultural policy we need a concerted effort to bring about national integration. Now these are new values and new social objectives which arose as a consequence of the independence of our country, and the problems before educationists and those who manage and develop educational materials is how to build these values in various disciplines positively, and - on the negative side side - how to identify and, if possible, eradicate contrary trends which tend to persist and are even generated afresh time and again.

I wish to indicate by these comments that there is a close relation between social objectives and educational materials and their management, and it is quite obvious that this is not a simple problem in which one country's experience can be of direct use to another. The situation is further made difficult by the fact that the countries with high aspirations for the future have scarce resources at the national level, and so also at the individual level where one cannot afford to buy even seemingly inexpensive material, where mass media like radio and TV have serious limitations. In our country there is, however, a great asset in the fact that we have a large base of know-how at all levels. We have scientists, philosophers, and educationists: we have technologists in all fields including film and television. Therefore, whatever effort we decide to make, recognizing fully the social responsibility and the complicated situation, we can potentially implement no matter what the software and hardware required may be.

The Central Agency of Development and Management in India

Before focussing attention on the specifics, let me indicate that while education is a State subject there exists a very powerful machinery for consultation, discussion and possible implementation. One of the facets of this machinery is the National Council of Educational Research and Training (NCERT). This is an autonomous body funded by the Central Government,

closely related to the governments at the Centre and the States because the highest policy-making organ of the NCERT has State Education Ministers as its members and is presided over by the Union Education Ministers. On the other hand, as far as its internal management and academic policies are concerned, it is free to make its own decisions. It is academically equivalent to the Central Universities. Thus the National Council of Educational Research and Training is an independent body, an academically-oriented organization, and yet its policies are practical and its priorities are realistically based. To a considerable extent in the field of education it can talk to the States irrespective of the political complexion of their governments because the basic objectives are not challenged by anyone.

The NCERT plays a very considerable role in all aspects of school education and certainly in educational research at all levels. It has departments with academics who can develop the total concept of school education in the form of a curriculum, with a consultative machinery of people from all over the country. It can cause textbooks, supplementary readers, teachers' guides and any other needed material to be written and produced. It develops kits useful for science education, mobile laboratories and television programmes and films. It has an apparatus for extensive evaluation of this material in the school system, and it also runs four Regional Colleges of Education to see how the materials fare in practice. The credibility of this Organization on the academic plane is very high, so much so that many States are now setting up State Councils of Educational Research and Training. The books produced by the NCERT and the kits developed by it have found favour extensively in the country and abroad.

Educational Materials

Textbooks

Textbooks are the most popular and perhaps the most important educational material. They are cheap and their content is explicit. But as I have indicated they are a very difficult material to handle in a modern educational system with a multi-lingual population. Obviously, no central organization can produce textbooks which could serve as more than a "model" in a country like India. This is because the States have their own academics who need not always agree with the contents of the centrally-produced material and also because different cultural, historical and environmental backgrounds have to be táken into account. Once the States produce their own books, there are two types of problem. One is that in each State there are linguistic minorities which may number as many as fifteen. The number of people belonging to some of the minorities is small and it is expensive to translate books for them. Books cannot be borrowed from the States sharing a minority language because the syllabus may be different. As a solution to this problem, we would like the curriculum to be divided into units which transcend the conventional boundaries of disciplines such as history or geography or physics or chemistry. The unit system has many other advantages but in the present context we believe that the States could take a large number of units from the central pool without change. Where they feel that their specific needs require different units they will have such units produced in the States. Therefore, it is possible that a large percentage of the curriculum, perhaps 60 to 80 per cent, could be common all over the country for a few years until it is reviewed by an adequate machinery of consultation. The common curriculum could then be translated into various languages and used in the school system. The problem of providing suitable books, or a collection of units, for the minority schools would then be reduced to the problem of multiple translation of the specific curricular units which a State wants.

The danger in a highly centralized curriculum, or even a core of the curriculum, is that the possibilities of modification and improvement are reduced; these possibilities require a multiple alternative type of approach. However, the decision has to be taken in the light of the cost involved.

One of the great problems we have faced in connection with textbooks is the training of authors. Academics are so straight-jacketed that they tend to perpetuate what they themselves have learnt. The needs of today's situations are very different as I have described earlier. Therefore, the training of authors is not only from the point of view of style or other techniques (such as illustration by suitable diagrams and the choice of proper exercises), but in the substance of what they want to communicate. This is a problem which is being tackled and we are gradually building up a group of resource persons in every State.

In connection with textbooks, it may be mentioned that the NCERT's textbooks are produced through a system of subject panels. Once the curriculum is identified and the scope of a particular subject in that framework is made clear, level by level, a number of people who are subject experts and those who have been teachers in schools are assembled to discuss further details. The draft of the book is written and circulated widely for comments and, where possible, tried out in the schools for some time. A stage then comes for the book to be printed and made available at cost price. In the States there are two systems; one is similar to the NCERT process and the other is a system of approving textbooks produced in the private sector. The books published in the private sector are more expensive, quite often two to three times more expensive. Hence, there has been a tendency for the States to enter this field more strongly over the years. The practice of different institutions selecting books on the advice of their own staff or committees is giving way to the practice of accepting the books prescribed by the Boards which conduct school-leaving certificate examinations or the State Departments of Education.

Films

We have a Central Films Library in the NCERT which has thousands of selected educational films available for loan to subscribing institutional members. In the States too there is a facility of distributing films. Here again one of the most important problems is language. A large number of good educational films available are in English and since education in the mother tongue was adopted as our policy, children are unable to really benefit from these films. Besides, the overall content of the English language films is alien to the way of life in our country and this proves, at least, to be a distraction. Therefore, there has been considerable effort and emphasis on indigenous production of films.

The NCERT has made a number of scientific films, particularly those which go with the science kits, but the problem is to have the films available in a large number of State languages. Various techniques are being tried out. Since the educational films rarely use direct speech by those who are on the screen, the problem of synchronization is simpler, and the technique of having a cassette recorder with the commentary in different languages fed through the amplifier of the projector is being used successfully.

The purchase of films as well as the preliminaries to the production of films are based on committee work where subject experts as well as educationists are involved. We have a large programme of producing various kinds of educational films in the country. Some of our efforts at the moment

are directed at the satellite instructional television experiment (SITE). The Ministry of Information and Broadcasting and the Indian Space Research Commission are handling the software and hardware respectively but a number of educational films are being made by other organizations. The NCERT is making films for teacher training in SITE. These are not programmes of institutional education because the television audience would be a mixed age-group. These programmes have been so carefully worked out that every village where the receiver is installed was studied for its sociological aspects.

Tapes

Video and audio tapes have also been recently taken up for extensive use in the educational system. The programmes connected with the satellite are mostly on video tapes, and experiments with video tapes in educational institutions are being done in a number of places. As far as audio-tapes are concerned, these are being made on a small scale to supplement correspondence education and also to provide general education. One of the projects in hand is the collection of tapes of important cultural, scientific, political and historical events which are already available in the archives of various agencies in India, and to edit and add commentaries to these tapes so as to interweave them in educational programmes.

Science Kits

Science kits have been developed at the NCERT for the first eight years of schooling. These kits are of great importance because education in science is to be compulsory in India up to class 10 (i.e. for students of age 16+). Education in science is also likely to contribute to the development of a more rational and a more open outlook which would be conducive to strengthening concepts of human equality and national integration. These kits are quite inexpensive and their development was based on a great deal of consultation with experts and trials at schools. The kits are accompanied by instruction manuals and they have lately been strengthened with corresponding films. The project was assisted by UNICEF and the kits produced were distributed to a number of schools in the States. Although the number of schools receiving the kits ran into some thousands, that was a drop in the ocean because we have approximately 600,000 schools. The States have now taken over the task of procuring kits for their schools. Extensive facilities for training of teachers to use the kits were provided by the NCERT and by the State Education Departments. A number of teacher training colleges and schools have also been provided not only with the kits but with some other science equipment to strengthen the training of teachers.

Resource Centres

A national centre for textual materials was set up in the NCERT. Textbooks from all the States were collected and placed in the Centre but the development of the Centre has been stifled for various reasons. The periodic change of prescribed textbooks is a great problem. At the moment a large number of centres are operating in the country which may be called resource centres. There are State-run and private organizations, called community science centres, where a good deal of material is displayed, where students can work on scientific projects or in the workshop, and where training is provided for teachers. Of course, there are film shows and exhibitions connected with these centres. Some teachers' organizations have voluntarily started resource centres in district towns. These work in a manner similar to the teachers' centres in England. They have textbooks and other books to benefit the teachers in various subjects and some of them have facilities for showing

films and even for producing teaching aids by mutual assistance. There are also extension service departments attached to teachers' colleges which have a selection of instructional aids and materials. But admittedly in this field we have not made a great deal of headway.

Museums and Exhibitions

The use of museums and exhibitions, particularly to strengthen the teaching of science, has been given considerable attention in the last few years, and mobile laboratories and museums are being assembled to help the schools particularly in the rural areas. There are programmes of adult education in the country which would involve the setting up of a large number of Nehru Yuvak Kendras (Nehru Youth Centres) which would have facilities similar to a district-level resource centre. A large number of such centres have already been established and are functioning with a great deal of local initiative.

We have not undertaken any extensive studies on cost-effectiveness of educational materials or establishments. But this is admittedly an important aspect to develop. At the moment one is guided by certain broad concepts and values with respect to the various materials and media.

THE USE OF LOW-COST SCIENCE EQUIPMENT IN SCHOOLS

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According to the Commonwealth Secretariat publication, The Production of School Science Equipment, there are over a hundred bodies and organizations working on the production of school science equipment. Most of them merely turn out prototypes, but a few are engaged in mass production. It is clear that blueprints and good ideas on equipment production exist in plenty. What appears to be needed is knowledge of how the items of equipment made by these production units are received by the teacher and used in the classroom.

The absence of any systematic studies of evaluation of school science equipment is common knowledge. Professor Rais Ahmed, Director of the National Council of Educational Research and Training (NCERT) in a paper presented to the 1975 New Zealand Conference on "Materials for Learning and Teaching", admits that NCERT, a leading organization operating in this field, has not "undertaken any studies on cost-effectiveness of educational materials". Also, in the Secretariat publication already cited above, Warren and Lowe note that in the South-East Asian regional body, RECSAM, "work is seen as involving engineering and educational effort but without systematic analysis of the varied classroom situations into which the apparatus must fit...". My own experience in the Science Equipment Production Unit (SEPU) confirms the above observations: no evaluative studies have been carried out on how the locally produced kits, numbering over two thousand, are being used in schools. The content of this discussion paper is therefore necessarily general.

Individual Student Experimentation/Teacher Demonstration

School practical work is often divided rather rigidly into categories - individual student experiments, and teacher demonstrations. Current curriculum development favours work on an individual basis and much effort is being made in many developing countries to persuade teachers to move away from the more traditional and familiar method of demonstration. We should not forget that we are considering a group of very inexperienced teachers, a high proportion of whom are generally untrained and whose approach to science teaching usually consists of a series of lectures with the occasional demonstration. This pattern of teaching is further encouraged by the extremely limited budgets on which schools run. We are faced, then, with a dilemma; on the one hand it is educationally desirable to move towards student experimentation, but on the other there are the constraints imposed by lack of money and experience.

This dilemma is of fundamental concern to those involved in the production of low-cost science equipment. Production units are, we hope, closely associated with other curriculum development projects and so are involved in implementing new teaching strategies. As an example, one of the practical aims of the SEPU kits has been the encouragement of an investigatory approach which will improve both the general standard of science teaching and the interest displayed by students.

Quite apart from any educational considerations, it is necessary to look at a purely business factor. For local manufacture on a commercial scale to be economically viable, there must be a sizeable market. Let us consider India as an example. Middle schools alone number over 100,000. NCERT, therefore, has no problems as far as size of target population is concerned. In fact, the market is so large that NCERT is able to afford to put up two categories of kits; one for teacher demonstration and the other for individual student experimentation. In the case of Kenya, however, there are only 1,250 secondary schools. For SEPU to consider the manufacture of any item of equipment it is necessary to have a production run of at least 1,000. In this case it is obvious that the market is simply not large enough to justify the development of a demonstration kit. Thus SEPU is at present concerned mainly with the production of individually-based science kits.

SEPU recommends that students use kits working in small groups (four represents an ideal number) but, at the same time, it acknowledges the fact that many of the poorer schools are forced by their financial situation to limit themselves to a single kit. This means that any teachers' manual designed to accompany the apparatus must take into consideration the fact that some of these kits are being used for demonstration purposes; adequate instructions need to be provided both for work in small groups and for teacher demonstration exercises.

Storage

Little thought appears to have been given in the past to storage although many teachers see it as a major problem. A high proportion of rural schools have a science room rather than a fully furnished laboratory. Such rooms are not only devoid of apparatus but also of storage facilities. One of the objectives, then, must be not only to design a kit but also something to put it in. Wood is the obvious material. It is usually obtainable locally, and labour presents no problems. Most units do design and build boxes from wood and hardboard, but occasionally experiments are carried out with other materials. SEPU at one stage packed their kits in plastic moulds in a cardboard box but this turned out to be no cheaper than a wooden box, and far less durable.

A second consideration is that many science kits, by their very nature, contain a lot of separate parts. Losses are very likely and a kit in which half of its components is missing is of little use to anyone. Thought needs to be given to this. A solution that has been tried is the design of special fixtures to hold individual items. NCERT had this to say concerning a biology kit in one of its reports. "There will not, therefore, be any mix up once the teacher knows the position of various pieces of equipment." Experience in Kenya does not confirm this. The more specialized fixtures and compartments there are, the less likely it is that a teacher will put everything away. This is particularly apparent when dealing with kits on individual basis.

A third point concerns sales. In Kenya, kits are sold on an individual basis. A school may buy as many as ten kits, each being a complete set of apparatus from which the pupils need to select appropriate items for each investigation. Such a selection is not necessarily a delicate operation, and constant rummaging in kit boxes tends to damage the more fragile components. SEPU staff have, during in-service courses, suggested to teachers that in cases where a school possesses several kits, teachers should consider re-packing them in such a way that a small number of items may be withdrawn so that checking for loss becomes easier.

Although the whole area of storage is very much a problem for individual teachers in individual situations, production units do have a responsibility to design suitable containers which offer flexibility in use and are durable. Perhaps the best answer is a strong wooden box divided into a limited number of smaller compartments.

Maintenance and Repair

Design of low-cost equipment must also take repair and maintenance into consideration. Many reports freely discuss local repair, but their writers rarely seem to understand what this really involves. If an item can be mended with a hammer, then local repair is a possibility; if not, then it is much more realistic to think in terms of what the teacher can do for himself. Such routine work as polishing perspex lenses with toothpaste and softening hard modelling clay with glycerine is best included in the relevant teachers guide.

In any appraisal of the possibility of repair work, it is often not the teacher's ability but his inclination which is in doubt. The best all-around solution is to produce individual items which are as robust as possible but, at the same time, are inexpensive and stocked by the production unit in adequate quantity. The teacher will then know that he can purchase replacements cheaply at any time. This would appear to be an extravagant use of resources, but experience from SEPU indicates that in practice few science kits have items that are amenable to simple repair work, and a lack of skill or motivation on the part of many teachers means that what is broken often stays broken.

Administrative Programmes to Ensure the Teachers Actually make use of Equipment and Use Equipment Effectively

The report of the New Zealand Conference already referred to made the following recommendation: "Educational authorities should ensure that teachers receive as an integral part of pre-service and in-service training, whatever instruction they need to enable them to take full advantage of the equipment and materials that may be available to assist them in their work". A survey of the literature reveals that this statement confirms the sentiment of many production units. The need for teacher training programmes accompanying the introduction of a new range of low cost apparatus is clearly seen but is the most effective use always made for the time available?

For any programme of courses to be effective and successful, it ought to be tailored to meet the particular needs of the local situation. It might be worthwhile here to describe a specific case using as the example - the teacher training programme established by SEPU in Kenya.

Some of the problems faced by the schools for which the SEPU kits are primarily intended may be summarized as follows:

(a) Academic Qualification

Of the approximately 1,250 secondary schools in Kenya, some 850 are either private or are built on a self-help basis to serve a local community. The rest are government aided. Figures published by the Ministry of Education show that all secondary schools are staffed largely by non-graduate science staff. Although many of them are enthusiastic and very able teachers, a high proportion do experience problems of an academic nature at the form 4 (East African Certificate Education) level. In the non-government sector, the teacher shortages

are acute particularly among the science subjects; vacancies tend to be filled on a temporary basis by secondary school leavers. While every opportunity must be taken to raise the academic standards of these teachers, the problem is how one could do this and at the same time, avoid damaging the little confidence they possess.

(b) Inexperience

Part of the above problem is the relative inexperience of science teachers. With the shortage of trained science graduates, promotion to non-teaching posts of responsibility is rapid. As a result, it is unusual to find experienced African science graduates as heads of science departments.

(c) Lack of Confidence

Although much pre-service training is centred on new approaches to science teaching, teachers are extremely reluctant to depart from the patterns that they were familiar with as students. Once teaching practice is over, there is a rapid reversion to what is referred to as "traditional teaching" - a series of lectures relieved by occasional demonstration exercises. Behind this is a fundamental lack of confidence in ability.

(d) Poor Motivation

However distasteful, poor motivation of teachers is something that must be accepted. A significant proportion of teachers lack the necessary commitment to their profession, and this needs to be recognized and adequate plans made to overcome it.

Aware of the problems described above, a series of interesting and promisingly useful courses were planned to promote an interest in and encourage correct use of science kits. For the benefit of participants from the non-government sector, the courses were designed to include some basic educational theory and classroom technique.

The diagram provides a summary of the scheme for in-service training devised by SEPU. Initial planning and development were the responsibility of the biology consultant at SEPU. Having been a key person in the design work related to the biology kit, his teaching experience in Kenyan schools ensured an awareness of the problems that had to be faced. The basic plan was to provide a series of one-day courses, each involving as much teacher activity as possible throughout the provinces. The courses were designed on a unit plan, combining a local adaptation of some of the material developed in the U.K. Science Teacher Education Project, with opportunities to use the science kits.

The diagram illustrates the training available to an individual teacher. He has the opportunity to attend an introductory course at which he will be able to examine and use some of the science kits and familiarize himself with relevant teaching methods. Follow-up courses held later will enable him to go into greater depth in some of the experimental work as well as providing him with practice in other teaching skills. Finally, if he is still interested, he can continue to gain experience and help through half-day practical sessions which are organized locally.

Part of the long-term plan was to identify and train the necessary

personnel to conduct similar courses at a later date and to follow up the introductory programme. Fortunately, an excellent relationship was established with the Inspectorate Division of the Ministry of Education. Since follow-up work to a course of this nature is absolutely essential SEPU has started to make use of provincial organizations in this aspect of its work. With finances very limited, this has been centred on existing local organization and help has been received from the Ministry of Education's provincial inspectors, the British Council and, what is potentially a very valuable link, the Kenya Science Teachers' Association. SEPU provides assistance by way of personnel and equipment.

Unless attendance during in-service courses is made compulsory (and this is not the policy in Kenya), it is impossible to reach every teacher in this way. Alternative strategies are necessary. Most important of these is an adequate teachers guide. The biology kit guide, the latest in the line of SEPU teachers guides, tries to meet the same objectives as the courses. It is in two sections, a short introduction which puts in simple language some advice on teaching method and a main part which discusses each investigation in turn. Throughout the booklet, a compromise has been made between providing full information and at the same time keeping the guide brief enough to appeal to readers.

Experiments have also been made in conjunction with school's broadcasting. Radio programmes have been produced which, although directed at the students, incorporate an element of teacher training. Because these programmes have not been broadcast at the time of writing this paper, further comment is not possible at this stage.

The in-service training of teachers is expensive. A brief examination of the financing of the SEPU programme may be of interest here. The largest items on the budget are the transport expenses and accommodation for teachers. These have usually been kept to a minimum by running identical one-day courses on a provincial basis. The cost of a teacher's transport and subsistence is met from the appropriate vote by his school. SEPU pays for staff accommodation and transport In a series of six introductory courses for which full records were kept, it was found that SEPU spent approximately 3,000 Kenya Shillings. It is of interest to note, however, that in the month immediately following these courses, sales resulting from orders made at these courses amounted to 35,000 Kenya Shillings!

The situation with pre-service training is not satisfactory. Progress has been poor but it is hoped that better liaison between institutions that train science teachers and SEPU will lead to closer co-operation in future. Outside of this experience, it must be remembered that once a production unit starts manufacturing science apparatus in quantity, note must be taken of this fact by training colleges and universities preparing science teachers, whether or not they are in full support of the scheme.

Evaluation of Equipment by Teachers

Formative evaluation should be a basic concern of any production unit. It is essential to have continuous assessment and feedback from the classroom. Much has been written concerning this subject (see the New Zealand Conference report on "Materials for Learning and Teaching") already and so, here only the importance and role of the teacher in evaluation is considered. Close co-operation between the evaluator, however experienced, and the teacher, however inexperienced, is vital. The fact that this is not recognized probably leads to more failures than any other factor in attempts to gain information at

the school level. A look at some recent, small-scale evaluations reveals a number of points worthy of note:

(a) Teachers are busy. They have many more important jobs to do than fill in circulars. It is reasonable to ask a teacher for ten minutes of his time, but questionnaires that take an hour or more to complete are unrealistic. Similarly, a teacher is more likely to return the information promptly if he has to tick the appropriate box rather than supply a detailed report in answer to every question. A further practical point that is easily forgotten is that certain times in the school year are much busier than others. Avoidance of the examination period period, for example, will be much appreciated.

(b) The aims of the evaluator are often not clear. The teacher should know why he is being asked to supply particular information and to what use it will be put.

(c) There are obvious advantages, mainly in terms of a saving of time and money, in conducting an evaluation by means of postal circulars. Unfortunately, the number of such circulars that are returned can be depressingly low. If circumstances permit, it is better to establish personal contact. A structured interview can produce more satisfactory results since points can often be clarified where necessary.

(d) It is important that the evaluator asks his questions in the correct way. In the early work of SEPU, an attempt was made to determine the needs, in terms of apparatus, of science teachers. Teachers were asked a question like, "Would you like a model of a DNA molecule?". Obviously, no teacher was going to look a gift horse in the mouth. When the results were analysed it was found that "95% of teachers would like DNA model". In this way, an item completely unjustified in terms of cost-effectiveness was included in the prototype kit.

SUMMARY OF SEPU IN-SERVICE TRAINING SCHEME

PROGRAMME OF TRAINING AND SUPERVISION FOR THE EFFICIENT USE OF EQUIPMENT; AND THE DISSEMINATION OF INFORMATION RELATING TO THEIR USE

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With the acknowledged new methodology and efforts in science teaching, the use of apparatus and materials for instruction assumes a very important role. However, in a non-technological developing country, manufactured school science equipment is hard to obtain. Imported materials are expensive; it takes a long time for them to arrive; and it is not unusual for those ordered from abroad to arrive so late that the topic has been taught without them or the teaher requiring them has left the school. Besides, imported materials are often inappropriate and do not meet the needs of local curricula. Thus when educational materials are required, more attention should be given to the need to utilize local resources which are familiar and readily available to the teacher and learner alike.

In providing school science equipment, the specific requirements of individual teachers should be borne in mind. Mass produced materials are not always appropriate. In addition, teachers and allied workers may have to be provided with training and supervision for the efficient use of equipment.

<u>Types of School Equipment and Construction Tools required</u>

School equipment required to teach the various branches of science are classified for the purpose of this paper under the following categories:

(a) mechanical - balances, pendulums

(b) electrical - meters, electrical circuits, machines

(c) wooden - trolleys, cages, racks

(d) metal - stands, dissecting instruments

(e) glassware - receptacles, thermometers

(f) plastics - containers, models

Tools required to construct the above types of materials include heavy machinery, such as drills, saws, lathes for wood and metal; simple hand tools including drills, saws and a hammer; welding and soldering equipment; glass and plastic moulds, and blowing equipment.

Since teachers rarely possess the skills needed for using construction tools, and since schools in most developing countries are hardly ever

provided with qualified laboratory technicians, it is necessary to provide facilities for training teachers and technicians in constructing school equipment.

This paper therefore deals, from the viewpoint of a curriculum developer, with training and supervision for the efficient use of construction and science teaching equipment made from local or foreign material.

The kinds of construction tools required to construct the categories of apparatus listed earlier are:

(a) tools for wood working - cutting, drilling, turning equipment

(b) tools for working with glass - melting, moulding, blowing

(c) tools for working with plastics - melting, moulding

Because heavy equipment is expensive and therefore not widely available, it is best provided as part of a national equipment construction centre which also serves as a training centre.

The Science Curriculum Development Centre, Njala University College as a National Training Centre

The Science Curriculum Development Centre (SCDC) at Njala has for long been the national centre for science curriculum development in Sierra Leone. The Centre has been involved in producing primary science units based upon materials and phenomena in the local environment. The tools and equipment used in their construction are made from readily available materials in the environment.

SCDC has also been working at the in-service level with primary school teachers and school administrators, such as headteachers, inspectors and supervisors of schools, to train them in curriculum development and the efficient use and construction of simple locally-constructed scientific equipment.

Simple equipment which has been constructed include items dealing with:

(a) measuring - balances of various types, measuring wheels, water-clocks, thermometers, pendulums and gears

(b) electricity - bulb and battery holders, switches, galvanometers, electric motors and electrolytic cells

(c) heat - condensers, oil burners, solar furnace, water turbine, oven for drying plant materials and chemicals, hatchery

(d) construction - wooden pedal-operated lathe, saws, hammers, chisels, screw-drivers and knives

Others include such items as cages, traps, dissecting sets, water-drop and bead microscope, periscope, test-tube racks, holders and tongs.

The imported construction equipment available at the Centre includes two heavy saws, one floor-mounted drill, three table drills, soldering equipment, and hand tools like saws, chisels, hammers, pincers and pliers.

The construction workshop is manned by a laboratory assistant who is untrained in the area of school equipment production but has been in the carpentry trade for about twenty years. As a technician, the laboratory assistant does simple construction work with metals and electrical components. He works very closely with the Director of the Centre, and although he has no formal training or qualification his productions are always of high quality. Attempts have been made for him to be given a bursary to gain further training and experience in school equipment construction, but because of his weak academic background he has always been rejected despite the high regard in which he is held by the staff of the Centre. Attempts to secure a more qualified technician in this area have been unsuccessful because the few technicians available in the country either do not find the work exciting enough or prefer to find employment in the basic or applied science sectors of the university and by industry.

Though the human and material resources at the Centre are very limited, SCDC has made some contribution in sensitizing teachers, students and pupils to the use of local materials for teaching and learning science. When SCDC was set up as a national training centre, it brought together primary school teachers, headmasters and school inspectors for the purpose of introducing them to the instructional methodology of discovery science. This was achieved by getting the teachers interested in local materials and encouraging them to try to discover things about these materials. To carry out these studies, equipment and other items had to be constructed. Most of the teachers, however, were found to lack the skills required to use the tools at the Centre. The technician successfully eliminated this handicap by means of instruction and demonstration exercises. At national workshops that have followed this initial effort, the Centre has always made use of the additional services of the chief technician of the physics department in the University College. Also, the workshop participants who want to use heavy construction equipment are encouraged to do so under the supervision of the construction workshop technician.

With the teachers becoming increasingly aware of what they can learn about things in their environment, and the fact that they recognize the possibility of using low-cost science equipment for this purpose, participants would like to be able to construct many items to take back to their schools. This, of course, is usually not possible due to the very poor financial resource of the Centre.

A possible outcome of a teacher's experience at the National Centre would be in recognizing the potential that exists within the local (and possibly rural) environment for teaching science. Efforts have been made to establish teacher centres which would serve to bring teachers together to exchange ideas and to discuss with the view to solving their problems.

Between 1970-72, teacher centres were set up at Bo, Bonthe, and Freetown. These were expected to co-ordinate with the National Centre so that advice and materials could be passed on and so that staff could exchange visits. However, due to shortage of staff, inadequate transport facilities, and lack of funds at SCDC, it was not possible to effect a reliable working

relationship between SCDC and these teacher centres.

Again as a national centre, SCDC was to have provided regular training opportunities for workshop organizers who would be placed in charge of the teacher centres. It was envisaged that in this role SCDC would allow three to five teacher-demonstrators to be attached to the Centre for a period of up to three months after which they would return to their local centres. Apart from the fact that this arrangement would have increased the professional competence of these local organizers, these trainees with field experience would have augmented the SCDC staff, thus making the Centre a more viable National Centre providing in-service training for teachers. Unfortunately this proposal, to date, has not materialized.

At the national workshops, ideas on equipment required for science teaching are introduced by the teachers. Prototypes arising out of such ideas are constructed and tested and, if found suitable, become part of the items of equipment for use by teachers.

Most useful ideas on school science equipment are born when particular problems are being studies. For example, a teacher engaged in experiments to study the passage of electric current through a coil of wire soon realizes the need to hold two or more batteries together. He may then decide to solve the problem by constructing a battery holder of a certain size and shape using readily obtainable materials such as plywood or wood from old packing cases. So he takes a hammer, nails, and a saw and produces the required device.

The SCDC has not as yet beeen developed into a centre for mass production of school equipment. To embark on this venture, the Centre would have to be provided with more technical staff and a building with adequate workshop space and more heavy machinery and technical personnel. Plans, however, have been suggested for the Centre to embark on mass production of certain materials. The Centre could also act as a maintenance unit for servicing school science equipment around the country. This service can be provided if a roving technician is available to visit schools and help with repairing equipment on site. Those items of equipment requiring major repairs would be taken back to the Centre where better facilities might be available. This proposal was made a few years ago when the Centre was in contact with a CUSO volunteer who was willing to undertake such service, but up till now the proposal has not been implemented.

In-Service Training at Local Level for Teachers

The Science Curriculum Development Centre has been involved in in-service training for teachers at the local level for a number of years. In 1970-72, SCDC staff travelled extensively across the country contributing professional service towards the training of primary and secondary school science teachers.

The in-service administrative set-up for primary teachers was tried at district level and then at town and village levels.

The district administration for these programmes usually included the Senior Inspector of Schools for the district; representatives of non-Government school authorities; headmasters of schools in the district; teacher training college tutors within the district; and the United States Peace Corps Associate Director for the area. The Director of the Science Curriculum Development Centre was usually invited to attend these organizational meetings at which schedules of in-service programmes were arranged, and brief explanation of the Centre's role in and facilities for the programme were usually discussed.

At scheduled dates, the staff of SCDC, loaded with hand tools and essential materials, would be present at the in-service course which might run for a period of 1-3 days.

These workshops were sometimes organized for the purpose of working with primary school teachers in subject areas like English, mathematics, social studies and science. Invariably, the SCDC had responsibility for the science aspects of such in-service programme.

From October 1970 to June 1971, the SCDC was involved in 54 off-campus in-service workshops; an average of six workshops a month. This field operation was made possible because the Centre had departmental transport donated by UNICEF and had an additional staff member appointed through the Education Development Centre with aid from the United States Agency for International Development. During these in-service workshops, instructors and participants, working with simple materials like discarded tins, cooking oil, razor blades, packing cases, knives, hammers and saws, examined the physical, chemical and biological properties of various substances. These practical exercises included investigations on the cultural, medicinal and other uses of plants. Though teachers found these courses professionally refreshing and useful, shortage of staff and lack of adequate funds have made it impossible for SCDC to maintain the high 1970/71 level of field operation.

In-Service Training of Technicians

In 1969, the qualified laboratory technicians of Njala University College initiated a training course for their colleagues who had not received previous training as laboratory technicians. Though the SCDC science educators were not directly involved with this course, they had informal discussions with the course organizers.

The classes were held in the evening and were arranged in the following hierachy:

(a)	Laboratory Apprentice Course	- for promotion to Laboratory Assistants
(b)	Laboratory Assistant Course	- for promotion to Senior Laboratory Assistants
(c)	Senior Laboratory Assistant Course	- for promotion to Laboratory Technicians

The syllabus for the Senior Laboratory Assistant Course was that of the City and Guilds Science Laboratory Technician Ordinary Certificate First Year.

The course structure was made up of an introduction to basic concepts of science, laboratory preparations and instrumentation. Concepts including organization of the laboratory for physics, chemistry, biology, first-aid, care of equipment, and advanced laboratory techniques. Courses were given in mathematics, biology, chemistry, physics and workshop technology. Workshop technology included the use of different machines and tools, including precision bench tools, micrometers and verniers among other things.

A major problem which the organizers had to contend with was that of funding; the funds required to provide extra materials for the course and the instructors' salaries were unavailable. Thus, even though the idea for the

programme was well conceived, the course could not be run on a regular basis. Regrettably, it was abandoned in 1975. With adequate facilities, a centre such as SCDC which is engaged in production of equipment could organize and run a technicians' training programme not only for the home institutions at the national level. Such a programme could be run at the pre-service and in-service levels.

In a technological society, laboratory technicians are expected to have the skills to repair and maintain sophisticated equipment. Only occasionally will they have to produce designs for improvised equipment. In a developing country, technicians are needed who can not only maintain and repair existing equipment, but are also able to improvise, convert old and out-dated equipment into other uses and use local resources and techniques to produce useful items of equipment.

A school or college laboratory technician in a developing country should be a workshop technician. He should be skilful with construction tools and not merely be available to prepare solutions, collect standard materials and wash up receptacles. The technician should be trained to recognize potential resources within the local environment and also to translate the ideas of the science teacher into workable school science apparatus.

With the necessary pool of laboratory or workshop technicians available to assist in science teaching, more effective teaching and utilization of local resource materials would be achieved. The science teacher would have the technical assistance to develop the equipment he needs, while at the same time he would have additional free time to develop effective teaching strategies.

Networks for Dissemination of Information on Successful Utilization of Local Materials

Various means could be used for the dissemination of information on successful utilization of local materials. These could be summarized as follows:

(a) Printed materials - pamphlets, handbooks, adverts, and newsletters

(b) Audio sources - cassette tapes and phonograph records

(c) Video sources - filmstrips, slides, and photographs

(d) Mass media - radio, television, and newspaper reporting

(e) Network of teacher centres

For these to be utilized, the informational materials should be available. The printed, audio-recorded and video materials have to be provided to portray the effective utilization of local materials. Such facilities as are required to record local experiences are usually hard to come by in a developing country. Even at the Njala University Campus where there is an Educational Service Centre (ESC) that develops printed and photographic materials, a film unit has not yet been set up.

The ESC records experiences in the use of local materials and produces these by lithographic reproduction. These materials, in the form of hand-outs, mini-units and unit booklets have been widely circulated and used in the development of the primary science programme.

Experience at Njala University College shows, however, that although these materials can be recorded and reproduced within a short time, it is usually difficult to collate the materials because the ESC is without a collator. This means that printed materials amounting to a thousand or more copies have to be manually collated. This procedure, of course, wastes much time and prevents useful materials from reaching recipients in good time. It would seem, therefore, that a well-equipped printing and reprographic unit centrally located and associated with the National Training and Development Centre would serve the purpose of producing materials showing the effective utilization of local materials.

When the informational materials have been prepared, they must be made available to teachers, teacher trainers and policy makers. This dissemination is best done through the national and local teacher centres. Apart from in-service courses at which teachers would be made familiar with the potential and use of low-cost equipment, information could also be disseminated through showrooms where both hardware and software materials can be exhibited. Such showrooms could be located at teacher centres and other sites around the country. This visual presentation at places within reach of schools would be a an incentive to teachers to use as well as innovate in low-cost school equipment production.

Although television could be very useful for the dissemination of such information, many developing countries do not yet possess a nationwide television system. Broadcasting on the radio lacks the visual presentation of television and is therefore not so effective.

COMMONWEALTH CO-OPERATION IN THE MANUFACTURE, SUPPLY AND USE OF SCHOOL SCIENCE EQUIPMENT

Paper presented by the Commonwealth Secretariat

This paper seeks to indicate areas in which the Commonwealth Secretariat can assist in promoting Commonwealth Caribbean co-operation in the field of school science equipment, and to identify the Secretariat's role.

The educational programme of the Commonwealth Secretariat can be described under three main heads: the organization of conferences, seminars and workshops; the collection and dissemination of information; and the organization and support of training courses.

Information

One of the main functions of the Commonwealth Secretariat is to act as a clearing house for information about educational developments in the Commonwealth. The collection of information is done in various ways, for example through visits to Commonwealth countries, through correspondence, and through the large number of journals and periodicals that the Division receives.

When necessary, the Secretariat may commission specialists to obtain information in specialized fields. For instance, it was as a result of a commissioned study that we were able to publish The Production of School Science Equipment. The Secretariat also organizes surveys in order to provide information required by Commonwealth countries.

The dissemination of information is effected through publications like the C.E.L.C. NEWSLETTER. The Secretariat also publishes reports of its seminars, workshops and other conferences, as well as results of surveys. There is in addition the Education in the Commonwealth series of publications dealing with special areas of education; such as Correspondence Education and the Education of the Handicapped. Among other publications are titles such as Educating and Training Technicians, Mathematics Teaching in Schools, and The Production of School Science Equipment.

Conferences/Seminars/Workshops

Commonwealth Meetings dealing with Education are handled by the Education Division. The meetings vary from ministerial conferences to specialist conferences and smaller meetings like workshops, seminars and symposia. Mention has already been made elsewhere to previous specialist conferences dealing with other aspects of education. The Secretariat has recently concentrated on the workshop/seminar type of meeting which, in addition to discussing problems in general terms, aim at providing an element of training for participants.

The purpose of this present Seminar/Workshop is to provide an

opportunity for participants to exchange views and information on the problem of providing science teaching equipment in the various Commonwealth Caribbean countries, and to consider solutions to the problems raised with a view to making the knowledge of science available to as many school pupils as possible through the local production of science teaching equipment.

Training

Training is provided and supported by the Commonwealth Secretariat in various ways, some of which are as follows:

(a) Bursaries: The Secretariat encourages Commonwealth countries to send personnel to train at courses which are already in existence. Emphasis in training is mainly on middle-level personnel and awards have been made for a wide variety of courses in technical and professional institutions. For instance, the Secretariat supported with bursaries the training of 25 technicians from Tanzania who went to India to train for the promotion of small-scale industries in rural areas. The Secretariat has also supported training in special courses at the East Caribbean Institute of Agriculture and Forestry in Trinidad and Tobago.

(b) Provision of Consultants: The Secretariat has often provided consultants to assist national training programmes. For example, the Commonwealth Secretariat was involved in the latest review of educational policy and programmes in Sierra Leone, and in 1975 a team of consultants was invited to advise the Government of the Bahamas on the organization and administration of their educational system.

(c) Regional Training: Where regional training courses exist, the Secretariat is prepared to consider requests for support of personnel sent there for training. It is at present in consultation with non-Commonwealth training centres with a view to getting them to accept trainees from Commonwealth countries. The Commonwealth Secretariat is itself trying to establish a programme of regional courses, in accordance with a recommendation of the Sixth Commonwealth Education Conference. It is usually agreed that regional training is worthwhile for two main reasons. First, training will be in the context of problems which are common to a particular region, and second, the cost of training can be reduced by avoiding the necessity of having a number of national training centres for the training of only a limited number of personnel. At one such centre, the University of Nairobi, the Secretariat is about to train personnel from Commonwealth countries in Africa in educational administration and supervision. This will be followed by a Caribbean course on certain aspects of book production to be held in Guyana. These are the first of what we hope will be a number of regional courses if demands for them continue.

(d) Educational Visits: The Secretariat has in the past provided a number of travel grants to enable personnel from developing countries to travel to other developing countries to examine special educational areas of interest. These visits have proved very useful. However, emphasis is now shifting to training attachments.

It is necessary for this Seminar/Workshop to consider specifically Commonwealth co-operation in the field of manufacture, supply and use of science equipment. Suggestions have already emerged. The Commonwealth

Secretariat has already been requested, for instance,

(a) to circulate information on developments in the field of school science equipment, and compile and publish a directory of audio-visual materials on a regional and pan-Commonwealth basis;

(b) to encourage the free flow of low-cost science equipment among Commonwealth countries;

(c) to investigate the design of basic equipment which can be used widely, especially where there is no supply of electricity;

(d) to encourage regional co-operation through standardization, production and distribution of locally-produced science equipment;

(e) to assist with programmes of in-service training of science teachers and with the running of regional science workshops.

Other areas of Commonwealth co-operation could also be considered. As has been done in other fields, the Commonwealth Secretariat would be happy to consider requests for:

(a) support for national training programmes either through the provision of consultants to help plan the programmes or operational personnel to assist with the actual training;

(b) provision of bursaries for trainees at centres already in existence;

(c) provision of travel grants for persons engaged in the design, production, distribution and use of low-cost science equipment.

Bi-lateral Co-operation

It is encouraging to note that the widening of the range of Commonwealth co-operation through the Secretariat has not lessened the importance of bi-lateral co-operation. Bi-laterial co-operation has given rise to a great number of exchange visits and a certain amount of technical assistance. The following could be considered as areas suitable for increased bi-lateral assistance:

(a) travel funds to enable visits of personnel to the donor country or a third country to see education projects;

(b) awards to enable personnel to train in the donor country or in other countries in selected fields;

(c) support for trainees at regional training centres;

(d) the supply of personnel to support national training programmes;

(e) the exchange of materials for the teaching of science.

Commonwealth Associations

There is room for Commonwealth associations as well as other international organizations to assist with the training of personnel. Commonwealth support

could be requested by any Commonwealth association (including Science Teachers' Associations and Teachers' Unions) willing to assist with training personnel for the manufacture, supply or use of low-cost science equipment.

Science Teachers' Associations can be particularly useful by encouraging teachers to train and by arranging in-service training courses.

Teaching About the Commonwealth

Sadly there is a great deal of ignorance in Commonwealth countries about what the Commonwealth is and what it has to offer to member countries. The Commonwealth Secretariat would like to see more teaching about the Commonwealth in schools. In Britain, the Commonwealth Institute, which is an independent body supported by most Commonwealth countries, has produced, for use in Britain, kits of materials which teach about the Commonwealth. The Secretariat would like to see this approach developed on a wider scale, and it is hoped that some of the materials that will be developed in individual countries will include kits suitable for local use in teaching about the Commonwealth.

The future of the Commonwealth will depend ultimately on the degree to which its members work together. It is for this reason that the Commonwealth Secretariat is anxious to stimulate, in every possible way, the knowledge and understanding necessary for effective co-operation.

BACKGROUND PAPERS

SCIENCE EQUIPMENT CENTRES I: NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING (NCERT)

Introduction

The NCERT was established in New Delhi in 1961 with a view to improving school education. In general it:

(i) undertakes, aids, promotes and co-ordinates research in all branches of education;

(ii) organizes pre-service and in-service training mainly at advanced level;

(iii) organizes extension services;

(iv) undertakes and organizes studies, investigations and surveys relating to educational matters or the appraisement of educational programmes;

(v) disseminates improved techniques and practices; and

(vi) acts as a clearing house for ideas and information on all matters relating to school education.

One of the six constituent units through which NCERT functions is the National Institute of Education. This Institute has a large purpose-built workshop where science kits are designed, developed and produced.

Workshop Department

This was established to:

(i) study industrially-manufactured equipment for teaching science with the view to improving its quality;

(ii) design, manufacture and organize the trial of new teaching equipment;

(iii) generalize and utilize local and foreign experience to design and produce teaching equipment;

(iv) produce new designs for manufacture by industry.

Workshop Staff

The workshop department has approximately 100 members of staff and, depending upon demand, also employs a daily labour force as required. The following chart outlines the structure of the staff, but a particular title does not necessarily reflect the actual duties of the individual. For example, of the technical officers, one is responsible for office administration: In the fine mechanic grade, two are in the packing section.

Recruitment of staff is done through national advertising, and the successful applicants are appointed to their appropriate grade and duties. A system exists whereby any individual who shows aptitude can apply for the relevant trade test and be upgraded.

There is much flexibility in staffing. Besides each individual having his specific duties, personnel can be co-opted for other duties; this flexibility enables heavy demand areas to be supplemented to smooth out bottlenecks when they look like occurring. It should be pointed out, however, that this policy can only be practised effectively when employer/staff relations are good.

Development of Science Kits

In developing kits, close liaison is generally maintained with the staff of the science and mathematics department of NCERT as well as with UNESCO specialists supplied under UNDP/UNESCO assistance. The interchange of staff that takes place when developing a piece of apparatus allows more than one individual to participate in the design at various stages. Trials of developed materials are carried out in a school near to NCERT. Where necessary, they are modified prior to inclusion in the kits.

During the development process the production of the apparatus is kept in mind so as to minimize alterations between the form of the prototype and the form of the finished product.

On completing the development of the item, workshop production drawings are produced and made available for anyone wishing to construct the apparatus.

Production of Kits

In addition to the facilities for constructing apparatus in the workshop department, a number of items are constructed by local manufacturers. There are currently some twelve commercial manufacturers who tender for the batch requirements of the kits. The procedure adopted by the workshop is to request tenders for a fixed number of items with the suppliers working to the strict requirements of the department. All items submitted to the workshop are inspected by selected members of the workshop staff, prior to acceptance.

By maintaining their own quality control standards, the reliability of the manufacturers has improved, particularly since the success of each manufacturer's tender rests heavily on the quality of his past products. New tender companies have to supply sample products prior to approval for tender. In addition, these companies also offer their products on the open market for purchase by schools. The department supplies a list of such suppliers to all schools who write to the NCERT for information on the availability of the kits.

Under the course-work activities of the science and mathematics department of NCERT, courses on quality control have been operated by the workshop. These courses have been organized for member state Ministries of Education who have provided Quality Control Officers to specifically monitor the quality of products when purchased from commercial companies. The participants have been instructed in the requirements of their duties and provided with a kit of instruments and samples purchased out of UNICEF funds.

REGIONAL CENTRE FOR EDUCATION IN SCIENCE AND MATHEMATICS (RECSAM)

RECSAM was established by the South-East Asian Ministry of Education Organization (SEAMEO) in 1967 with the main purpose of assisting member

states in the improvement of science and mathematics teaching and thereby providing the firm foundation necessary for meeting the scientific and technical manpower requirements of South-East Asian countries in the future.

RECSAM is located on the Malayan Teachers College campus, Penang, Malaysia. The Centre is administered by a Director who is responsible to a Governing Board appointed by the South-East Asian Ministers of Education Council. The Director is guided by an International Advisory Council in the development of the Centre's programme.

The programme at the Centre is organized under four broad headings - training, research, information and special services, and administration. The Training Division operates courses aimed at training key personnel in the modern techniques of teaching and evaluation in science and mathematics. The Research Division operates courses aimed at developing complete prototype units or modules in science and mathematics as well as conducting some pilot studies on child learning. The Information and Special Services Division produces and disseminates information and ideas through reports and other publications. It also maintains contact with appropriate institutions and bodies within and external to the SEAMEO region. The Administration Division handles the organization and running of the Centre.

Facilities

The first phase of the building programme involved the construction of hostel accommodation and a recreational block.

The recreational block is temporarily being used as the teaching/ administrative block. Its facilities include classroom/laboratory space, workshop space, stores, printing/duplicating space, resource area (the main library is at present located in Malayan Teachers' College building), dark-room for photographic work, office space for staff, dining room (now a general purpose hall), and administrative offices.

The hostel accommodation is located in close proximity to the teaching area and consists of some 100 units of single/double room accommodation. The hostel facilities include common rooms and laundry facilities.

In the second phase of the building programme, provision has been made for a new building which will have administrative/teaching block, two laboratory/workshop blocks, a library/information block, and a conference hall. It is envisaged that while one of the workshops will be used for course work, the other will serve as laboratory for production of prototype apparatus for the teaching of science and mathematics.

Functions

RECSAM undertakes the following activities:

1. Training programmes for key educators in modern methods of teaching science and mathematics.

2. Development of action-research techniques.

3. Critical study of selected pilot project materials.

4. Development of specific studies and instructional materials to be carried out as pilot projects.

5. Critical examination of research on curriculum materials and methodology.

6. Development of simple techniques in apparatus making, using low-cost materials.

7. Organization and conduct of professional seminars and workshops for educators.

8. Gathering of information and acting as a clearing house for science and mathematics education.

9. Consultation and special services for SEAMEO member countries.

10. Promotion of indigenous efforts in curriculum development.

Formal relations have been established with UNESCO, thereby providing mutual co-operation in matters and activities related to science and mathematics education. This link also enables the Centre to benefit from the provision of specialists and consultants when required.

Financing

In mid 1970 RECSAM became semi-operational with the completion of the first phase of its building programme, and this commenced the first five-year operational plan for the Centre. The total cost of the plan was projected as being US$8.7 million, of which the United States of America contributed 50 percent. The Government of Malaysia, as the host country, assumed responsibility for the capital and operating costs of the Centre, whilst SEAMEO had the responsibility for raising the special funds for the Centre's activities. The latter are generally raised through grants and donations, in cash or kind, from interested governments, organizations and institutions. The second phase of the building programme, aimed at providing the Centre with its own purpose-built buildings, is being financed jointly by the governments of the United States of America and Malaysia. Work on this phase commenced in 1975, and occupation of the premises is expected in late 1976.

The second five-year development plan commenced in July 1975. Since then, RECSAM has taken full responsibility for obtaining its own finances.

The responsibility for the total operational costs for the second five-year plan was taken over by the Government of Malaysia in June, 1975. The amount allocated was approximately M$4.6 million, with an additional M$3,150,000 for the construction of additional facilities in the building programme and for awarding scholarships and fellowships.

The breakdown of financing for RECSAM is listed under two headings:

1. Operational costs which include personal emoluments, services and supplies, grants and subsidies.

2. A special fund to cover training and research scholarships, seminars and conferences, Governing Board meetings, and personnel exchanges.

Staffing

RECSAM is staffed by tutors recruited from within the SEAMEO region, but specialists from outside the region are also on the staff. Also, the services

of short-term consultants are utilized as and when required, these services often being generously provided by governments throughout the world.

The following chart which shows the staff and posts for 1975/76 indicates the current organizational set up of RECSAM:

Courses

The Training and Research Divisions are responsible for the courses conducted at the Centre and work closely together. The courses were laid down in the first five-year plan and have been modified in the light of experience gained. The differentiation of responsibilities is best seen in that the Training Division runs courses aimed at training key personnel in the modern techniques of teaching and evaluation, whilst the Research Division's development courses are aimed at developing complete prototype units or modules, as well as conducting some pilot studies on child learning.

Courses are conducted in elementary science, elementary and secondary mathematics, integrated science, biology, physics, chemistry, and elementary and secondary science apparatus. Between 1968 and June 1975, some 900 participants have attended training courses at the Centre. Depending on the nature of the course/seminar/workshop, the period spent at that Centre by participants ranges from two to twelve weeks.

One of RECSAM's objectives is to make use of the "multiplier effect" for progress in science and mathematics by training key personnel who on their return home can then train others and influence development. Ideally, this would suppose that the catchment area should be senior educational administrators and educators, such as would be found in teacher training institutions. In practice, such individuals can seldom be regularly released for courses lasting for ten to twelve weeks. Courses at RECSAM are, therefore, attended mainly by personnel from the teacher/teacher trainer level. This does not negate the objective of the multiplier effect provided that when special courses for senior educational administrators are held, information is included about what has been taught to the teacher trainers.

Equipment Unit

In October 1973 RECSAM hosted a Regional Workshop on the "Production of Low-Cost Teaching Materials for Primary Science and Mathematics" which was sponsored jointly by SEAMEO and Deutsche Stiftung Fur Internationale Entwicklung (German Foundation for International Development). Amongst the recommendations of that workshop were:

(a) There should be established a regional equipment unit at the SEAMEO Regional Centre for Education in Science and Mathematics, with the following functions:

  (i) Designing and fabrication of prototype equipment for science and mathematics.

  (ii) Training of key personnel from the SEAMEO countries for designing and production of prototype materials.

  (iii) Acting as a clearing house for collection and dissemination of information regarding materials for science and mathematics.

  (iv) Exploring ways and means by which the science and mathematics equipment needs of the region can be met.

ADMINISTRATION

Academic Staff	Non-Academic Staff
Director (1)	Registrar/Bursar (1)
Deputy Director (1)	Financial Assistant (1)
	Personal Assistant to Director (1)
	Stenographers (2)
	Book-keeper (1)
	Clerical Officers (4)
	Clerical Assistants (2)
	Typists (2)
	Store-keeper (1)
	Assistant Store-keeper (1)
	Drivers (2)
	Office Boys (3)
	Maintenance Technician (1)
	House Servants (10)
	Gardeners (6)
	Watchmen (4)

TRAINING DIVISION

Academic Staff	Non-Academic Staff
Assistant Director (1)	Laboratory Assistant (1)
Training Officer for Science (1)	Laboratory Attendants (4)
Biology Officer (1)	Typists (2)
Chemistry Officer (1)	
Mathematics Officer (1)	
Physics Officer (1)	

RESEARCH, DEVELOPMENT & EVALUATION DIVISIONS

Academic Staff	Non-Academic Staff
Assistant Director (1)	Laboratory Assistant (1)
Biology Officer (1)	Workshop Technician (2)
Mathematics Officer (1)	Typists (2)

INFORMATION/SPECIAL SERVICES DIVISION

Academic Staff	Non-Academic Staff
Assistant Director (1)	Clerical Officer (1)
Information Officer (1)	Clerical Assistant (1)
Librarian (1)	Typists (2)
Library Assistants (2)	Library Attendants (2)
A.V.A. Supervisor (1)	
Graphic Artist (1)	

(b) Each member country examines the feasibility of establishing a national design and prototype production unit as a component of its curriculum development and/or bilateral assistance in establishing such a centre should be explored.

(c) Countries should decide on their own priorities for prototype equipment development which should cater for the present curricula in mathematics as well as science.

The Fifth Governing Board Meeting of RECSAM, held in September 1974 decided "that the Centre in its attempts to implement some of the recommendations of the Workshop should develop the necessary materials only to the stage of educational prototypes, and that the emphasis should be on the training of personnel who would be likely to be employed as designers in national equipment workshops".

The Training Officer (Science) who is a member of the academic staff is responsible for the technical component of the course work as well as arranging the specialist courses on laboratory management/equipment, etc. In addition, he is also involved in other duties related to his own academic discipline. He is assisted in his work by one workshop technician, two laboratory assistants and a laboratory attendant. The technical staff are locally trained by the RECSAM staff and by attending ad-hoc courses. At present the workshop facilities consist of a laboratory area equipped with hand tools and workbenches. The new building will have two workshops - one for course work and one for prototype design and development.

Those RECSAM courses that are related specifically to equipment are perhaps best described in the following extract from a paper entitled, "RECSAM's Programmes and Courses for Development and Production of Prototype Science Equipment", presented at the aforementioned Workshop:

> To assist each member country build up a core of equipment, key personnel who could develop prototype equipment and produce design plans for dissemination, as well as organize in-service training of teachers and laboratory personnel in equipment production, RECSAM has successfully implemented the course, "Development of Primary Science Apparatus" code titled RMI-1 in in 1972 and again in 1973. This intensive course of about ten weeks' duration is specially designed for SEAMEO key personnel who are actively involved in equipment design, development and manufacture in their respective countries, or who are in positions which make them likely to be so. So far, fourteen key personnel have undergone this course, namely, two each from Indonesia, Khmer Republic, Malaysia, Philippines, Singapore, Thailand, and one each from Laos and Vietnam.

The terminal behavioural capabilities expected of participants on completion of the RMI-1 course are that they should be able to:

(a) improvise simple science and mathematics equipment for use in the primary grades;

(b) carry out routine maintenance and minor repairs on simple equipment;

(c) transform new ideas for simple equipment into reality through designing, constructing and testing of such;

(d) produce an equipment design plan acceptable for publication with the necessary technical drawings and parts specification included;

(e) provide sound advice for the procurement of equipment from commercial sources;

(f) carry out refinements on prototype equipment for possible mass production;

(g) advise on plans for mass production of prototypes by government and non-government agencies;

(h) assist in development of curriculum materials through design, and development of equipment hardware for these materials;

(i) organize and conduct in-service courses for teacher trainers, teachers and laboratory personnel, to train them in the basic skills for equipment production leading to actual production of urgently needed equipment;

(j) play leadership role in science/mathematics exhibitions and in school science/mathematics activities.

The course work described above has been continuing and the Centre has a display area for apparatus developed.

Audio-Visual Aids

The Centre has an audio-visual aids specialist on its staff, and work in audio-visual aids is a constituent part of the majority of courses offered at RECSAM. A small darkroom is available where course participants are able to receive instruction in the use of photographic materials and techniques. In addition, sound space is available for using a range of audio and visual apparatus and for receiving instruction in the techniques of operation of the workshop facilities in the new building, an expansion of the A.V.A. facilities will also take place.

LOW-COST SCIENCE EQUIPMENT CENTRES II

KENYA SCIENCE EQUIPMENT PRODUCTION UNIT

Early in the 1960s almost all the science equipment used in schools in Kenya was imported from overseas. Its high cost precluded all but a few schools from buying the necessary quantity; even then this equipment failed to arrive on time and many items tended to be inappropriate to the conditions operating in Kenya.

With the launching of the School Science Project (SSP) in 1966 the existing shortage of equipment became even more acute as this new project was geared to individual experimentation and therefore required much apparatus.

At this time also the Kenya Science Teachers College (KSTC) - which had been set up with Swedish financial assistance in 1965 and whose programmes were in sympathy with the SSP trial syllabus - became concerned about how to motivate and assist their students to teach in the spirit of the SSP project in the face of existing shortages of equipment. It was at this point that the then senior technical physicist decided to develop a physics kit. Thus by 1969 a Production Unit had been set up within the Department of Industrial Arts of KSTC to design and produce this kit of equipment to meet the demands of the Kenya Junior Secondary Examination. Production proceeded on a small scale during the period 1969-1970.

Science Equipment Production Unit (SEPU)

To make the production efforts more successful, it was found necessary to set up within the College a Production Unit which would aim to be independent and economically self-supporting. The workshop, occupying an area of $265m^2$, was completed in 1970. It has since been expanded and now occupies an area of $960m^2$.

The principal machine tools supplied for KSTC Production Unit are as follows:

Metal work: 3 lathes, 1 milling machine, 1 pillar drill, 1 band saw, 1 hack saw, 2 grinders, 1 oxyacetylene welding set, 1 arc welding set, 1 sheet metal roller, 1 manual guillotine, 1 bending machine.

Wood work: 1 circular saw, 1 band saw, 1 planer (3m), 1 thicknesser, 1 large belt sander, 1 spindle moulder, 1 bench mounted drill.

General: compressor (a recent addition).

SEPU Subscribers

Towards the end of 1971 a KSTC policy decision led to the expansion of staff and the appointment of a full-time head of the Production Unit. Currently, SEPU is run as a company under a seven-man trusteeship. The trustees are the Director of Education, Ministry of Education; the Permanent Secretary,

Ministry of Finance and Planning; the Kenya Science Teachers College; the Kenya Institute of Education; the National Council for Science and Technology; the Jomo Kenyatta Foundation; and the Kenya Technical Teachers College.

According to a Kenya/Sweden agreement signed in June 1976, the Swedish government will continue to provide financial and personnel support to the company until 30 June 1979 when it is hoped SEPU will be completely self-supporting.

Production Strategy

In developing the various items in the physics kit, the following approach was adopted to ensure economic viability and efficiency of the project. As far as possible (this has subsequently been adopted for the production of the chemistry and biology kits).

(a) In consultation with the physics panel of the KIE, a list of the most acute apparatus needs of schools was produced by the head of the unit and the designer.

(b) The needs were then matched to the availability of raw materials, the amount of design work needed and the difficulty of production. At this stage an order of production priorities was agreed.

(c) For each item the Designer produced one or more prototypes and calculated an order of magnitude cost. The costing procedure adopted was as follows: cost of materials + 10%; cost of labour + 20%; running cost of machines + 40%.

The additions to the raw costs were to account for:

(a) The cost of materials lying on shelf awaiting use, or of finished items awaiting sale.

(b) The higher salaries paid to supervising and development staff.

(c) Sales costs.

(d) Wear and tear of machines.

(e) The technical working of the prototype was vetted by the Head of the Production Unit.

(f) The relevance of the item to current syllabuses and likely sales were vetted by the Head of the Production Unit, and the size of batch determined.

(g) The Designer prepared the jigs needed for production with the help of the Head of the Unit, and arranged the sequence in which operations should occur.

(h) Once production started, continuity and quality remained in the hands of the Head of the Unit. At various stages in the production of a batch, items were subjected to tests devised by the Head of the Production Unit and the Designer. Any items failing these tests were either reworked or thrown away. In the early stages of 1972, the

initial failure rate was sometimes as high as 80% although the final wastage in a batch, after reworking was usually of the order of 7%.

Prices: Local versus Imported Items

The table below shows the prices of some of the SEPU items with those of imported equivalents as of August, 1973:

Item	Local Price (K Sh)	Imported Price (K Sh)	Type of Design
A.C. timer	45	160	Local
Dynamics trolley	90 (per pair)	165 (per pair)	Local
Wheatstone bridge	80	202	Conventional
3-d Kinetic model	85	430	Local
Ray optics kit (including cylindrical lenses)	53	110	Local
Optics lamps	30	84	Local

SEPU Science Kits

Kits have been developed to allow students to have experience in as much individual practical work as possible in physics, chemistry and biology.

The hardware materials in each kit are accompanied by written materials for teachers and students. More recently these software materials have been strengthened by slides and tapes supported by leaflets. Still more recent are the radio programmes that have been prepared as support for the biology kit.

Majority of the items in the kits have been developed locally. Since the three separate kits have certain items in common, schools are able to to cut down costs by buying a box containing say, a physics/chemistry kit.

As an illustration of the usefulness of the kits in teaching, the chemistry one is described here as an example:

The basis of the kit (50% of which is glassware) is the pegboard stand. This is a board drilled with small holes at regular intervals and supported vertically by two feet. Each piece of apparatus is mounted on the stand by means of a special stainless steel clip. The clip has a base which can be fastened to the stand with a screw and nut, and its diameter can be adjusted to hold all the pieces of glassware from the thermometer up to the beaker.

The pegboard is useful and convenient in several respects. Compared to the more conventional retort stand it is stable and light. Moreover it possesses many features which allow flexibility. For instance, it is possible to mount apparatus anywhere on the stand and at the same time see where one piece of apparatus is in relation to one another. More important for work in chemistry, the apparatus can be mounted away from the stand when heating is required.

Again one could cite a few other useful characteristics of the kit. For instance there is no bent glass tubing provided. When collecting a gas over

water (an exercise that is done frequently) say, the gas is led into a collecting test-tube through flexible plastic tubing. This type of arrangement does away with the rather cumbersome process involving the use of beehive shelves, gas jars, and thistle funnels. Further, despite the standard nature of the glassware involved, each component of the kit has been designed to be compatible with as many other items in the kit as possible. Thus the rigid plastic tube used as the electrolysis cell can be converted into a drying chamber for gases. With many other items fulfilling more than one function, it is estimated that at least 100 simple experiments can be performed with the set of apparatus contained in the kit.

When not in use, the apparatus can be stored in a plastic mould or inside a cardboard box but there is also a wooden box designed in such a way as to allow the apparatus of several kits to be stored.

Though in terms of the cost and approach the kit has considerable advantage a few problems have been noted in connection with its use:

(a) The kit is relatively small and is therefore not suitable for demonstration purposes.

(b) Many of the items in the kit are small and can thus be lost easily. Thus the organization of practical work has to be carefully handled to ensure minimum loss of these items.

(c) Although the chemicals required for the experiments are listed they are not provided. It is hoped, however, that in the near future a "chemical kit" would be developed which would contain all the chemicals required for the experiments in the EACE course.

(d) The pupils sheets do not contain any reading materials other than that directly related to the experiments. Consequently, pupils need additional support in the form of a text or other suitable background reading material.

TURKEY'S SCHOOL MATERIALS MANUFACTURING CENTRE (DAYM)

Establishment

With aid in the form of expert assistance and cash for machinery and equipment from the Organization for Economic Co-operation and Development, the Ministry of Education in 1961, set up in Ankara, the School Materials Manufacturing Centre (DAYM).

Functions

The main function of DAYM is to provide teaching materials for schools in Turkey and this it does by producing the bulk of the equipment and aids and by purchasing the remainder for distribution from local or foreign markets.

The Centre also serves two other functions:

(a) It holds in-service courses during summer months for science teachers in order to train them to use and to repair laboratory equipment.

Through mobile units located in ten centres, able science teachers travel around a province (particularly in deprived areas) helping science teachers with their teaching problems and introduce them to new methods and techniques in science education.

In general, a mobile unit consists of a van, science equipment and audio-visual aids. They also carry with them tools and small machines for repair and other equipment to carry out demonstrations in rural schools where at present it is impossible.

(b) It runs day and/or evening courses for apprentices as well as evening courses for people who intend to learn a trade.

The latter are adults or out-of-school youth. The courses concern machine tool operation, metal turning, die making, electricity, electronics, glassblowing, technical drawing and woodworking. Over 2,300 workers have, during the past ten years, received satisfactory training in this regard.

Structure

Though the Centre started with only 25 workers and four teachers in what was originally a day Technical School, the DAYM now boasts of a new building in addition to the old one, 580 workers and 18 workshops (soon to be increased to 30) manned by 34 teachers. The administrative staff are all ex-classroom teachers and still belong to the Teaching Service. Of the 34 teachers, four are qualified Engineers and four are Higher Education Technicians. The administrative set up includes: a Director, a Deputy Director, Head of Research Development Unit, Laboratory Chief, five Assistant Directors responsible for Personnel, Education, Public Relations, Commercial matters, and Production, respectively, and 18 workshop chiefs.

Financing of DAYM and Method of Distributing Equipment to Schools

DAYM is regarded as a Department and it is therefore financed as such by the Central Ministry of Education.

Each year, the Department of Educational Aids within the Ministry of Education receives lists of schools' requirements from the Secondary and Elementary Education Departments. These requests are processed and passed on to the DAYM which then produces and sends the equipment to schools through private transport companies. The schools report receipt of equipment to the Centre and to the particular Department under which it functions.

If in addition to this free supply of equipment certain schools need additional apparatus, they make direct contact with DAYM or local companies and pay out of their own school science vote. Records reveal that school requests are dealt with promptly and with very minimum delay.

School Science Equipment

Science equipment for primary, secondary and teacher levels in all types of materials - wood, plastics, steel and glass - are produced.

Also, apart from certain sophisticated equipment like miscroscopes and thermometers which are imported from Germany, the United States, Israel and Japan, most of the bulk of school science equipment is produced by DAYM. For instance, over 80% of the equipment required for teaching the adapted

Turkish PSSC-Physics (94 pieces of equipment which can be used to carry out 200 demonstration experiments) is produced by DAYM.

The table below indicates the number of sets of equipment and aid produced by DAYM and supplied to schools during the period 1970 to 1973.

Instructional Tools Given to Schools in the Years 1970-1973

Type of Instructional Tool	Number of Sets Given				
	1970	1971	1972	1973	Total
Lycee Modern Physics	88	94	105	100	387
Lycee Modern Chemistry	88	94	105	100	387
Lycee Modern Biology	70	76	90	100	336
Lycee Mathematics	125	126	150	100	501
Lycee Social Studies	115	445	200	100	860
General Science (Lycee + middle school)	60	670	220	500	1,450
Middle School Physics	100	40	340	-	480
Middle School Chemistry	120	40	340	-	500
Middle School Natural Science	100	40	340	-	480
Middle School Social Studies	100	210	350	500	1,160
Middle School Mathematics	125	152	300	500	1,077
Middle School Handicrafts	-	50	-	200	250
Primary School General Science and Natural Science	3,000	3,600	4,000	4,000	14,600
Primary School Social Studies	-	3,500	4,000	4,000	11,500
Primary School Handicrafts	350	-	400	400	1,150
Pre-School Education Instructional Tools	100	100	100	100	400
Middle School-Lycee, Lycee Level College Language Laboratory	-	9	10	10	29
Vocational - Technical Schools General Science	-	75	50	-	125
Grand Total	4,541	9,321	11,100	10,710	35,672

In the production of the above, the main raw materials imported are: optical glasses; chemicals for metal plating; resistance wires (chrome oxide); magnets (horse-shoe and bar types); Fe-Ni Aku Components (pure potassium hydroxide); semi-manufactured musical instruments components.

Maintenance of the Equipment in the Schools

Teachers are taught how to store and repair the equipment during in-service courses. Thus most of the small repairs are dealt with loc illy and major

repairs are carried out at the Centre. Machines at DAYM include the following:

	Quantity
Automatic coil winding machine	4
Diffusion pump (for glass blowing)	1
Machines for optical workshops	1 set
Checking and control devices for optics shop	1 set
Work dies for optics shop	1 set
Spring winding machine	2
Plastic injection press (for 2 kg. capacity)	1
Plastic injection press (for 1 kg. capacity)	1
Plastic injection press (for 1/2 kg. capacity)	1
Plastic blowing press (for bottle making - 2 litres capacity)	1
Lathe	3
Polyester spraying machine	1
Checking and control instruments for electric and electronic workshops	1 set
Special machines for the production of musical instruments	1 set

SPEECHES

SPEECH BY THE HONOURABLE LIVINSTONE N. COAKLEY

MINISTER OF EDUCATION & CULTURE AT THE OPENING CEREMONY

I am indeed happy to have the opportunity to welcome you and to share a few moments with you on the Government's view and focus on science education.

Today we live and work in a world that is fast developing into a technological and highly scientific society. My Government has taken note of this trend and has taken steps to improve our forward thrust in the area of science. Many new and innovative ideas are being introduced and present science courses are being updated. You will recognize readily that this is a costly process and we welcome workshops of this nature that will help us to cut some of the cost of materials that will be needed.

Ours is a science-oriented society. Our boys and girls become familiar at an early age, at their own level of comprehension, with the multitude of ways in wich the products of science become a part of their lives. At the adult level, those of us who will guide these children are aware of the ways in which science has drastically altered the dimensions of the world and of our lives. Therefore, we no longer hear the query of a hundred years ago, or even only a generation ago, of "Why should we teach science?"

Common agreement among educators has resulted in including the natural and physical sciences as one of the basic areas of the science school curriculum. But since far too many people think of science solely in terms of its launching of space capsules, its invention of new drugs, and its contribution to material comforts, the task of the science teacher must be carefully considered. The development within the pupil of a scientific attitude should be the goal of the science teacher.

The aim of an adequate science programme is to stimulate interest in the forces, phenomena, processes, materials, and living things, that make up a large part of children's everyday world. It is the aim of our science curriculum to help children acquire those scientific understandings, attitudes and skills which will foster personal development and full participation in a changing Bahamian society.

Recently my Government has initiated programmes and projects that will develop our students to what we hope will be a competent level of knowledge and appreciation for the world of science. Briefly, I would like to give you some idea of what steps we have taken to update and develop science education in our schools.

My Government is carrying out a major re-evaluation of both the content of and prevailing negative attitude toward the sciences and technical and vocational education, especially in the fields of agriculture and fisheries. No efforts will be spared, therefore, in determining the role of education in these areas and in accomplishing established goals.

In the primary schools the first structural curriculum for science education is soon to be introduced. It will cover grades one to six. At the junior secondary level three of the sciences are offered, namely General Science, Health Science and Biology. A few of these schools also offer Agricultural Science to their students. Curricula in these areas are presently being revised. Specialist teachers in the areas mentioned above are found in all of the junior high schools and central secondary schools with the exception of Agricultural Science. Specialists in this area are found in those schools which have Agricultural Science programmes. Students may write the Bahamas Junior Certificate Examination in General Science, Health Science and Biology at the end of grade nine.

Science subjects offered at the senior secondary level are as follows:

(a) Bahamas Junior Certificate level in General Science, Health Science and Biology:

(b) General Certificate of Education "Ordinary" level in Human Biology, Chemistry, Traditional Biology, Physics and Integrated Science:

(c) The Senior Secondary Agricultural Science syllabus was introduced at the beginning of this school year. Prior to this time, the Junior Secondary Agricultural Science syllabus was used as a basis for starting the programme in the senior secondary school. The syllabus is geared toward meeting the needs of the vocational and academically inclined students in this field:

(d) Marine Science is being gradually introduced into secondary schools in the Family Islands, and plans are also well underway for the development of Marine Science in one of the senior secondary schools in New Providence. My Government hopes to implement this programme in other senior secondary schools in the very near future. Qualified staff has been employed to work in this area.

There is an abundance of things in our Bahamian environment to interest and challenge us - things to watch, things to experiment with, things to investigate, and things to discuss. All the world lies before the student, to be explained and understood in its parts, and more important still, in the inter-relationship of these parts. Thus, an organized presentation is essential if the present generation is to grasp not merely facts, but inter-relationships as well.

One of the goals in my Government's ambitious programme is to restore the dignity of work with one's hands as well as one's brain. We are committed to making the fullest and most economic use of the cost of facilities and equipment for technical and vocational education.

I am pleased to say that within our midst are a number of industries that operate primarily on the scientific level. Among these are oil refining, oil trans-shipment, cement, rum and salt production. We are also blessed with the constant input by renowned scientists using the natural resources in our waters and land throughout the Bahamas, the Bahamas National Trust and the Agricultural Complex - BARTAD - on Andros. A growing number of Bahamians are entering the field of science and are lending their expertise to these industries. My Government is now in the process of getting our returning scientists into our educational system where they can share their knowledge and skills with our hopes for the future of our young people.

Our society and government today are convinced that education pays both economically and socially, and all evidence seems to support our convictions. Therefore, it is imperative that we continue to strive towards the improvement of our education in the field of science. My Government has begun and will continue to make strides to develop the area of science in the future. We are aware that scientific literacy is an asset to modern living. It is hoped that through our efforts to improve upon our present scientific status, all our citizens will be able to fully appreciate our world of technological and scientific advancement.

My Government would not advocate that teachers should sacrifice subject competence for psychological sophistication - but the time has arrived when we should expect a sounder appreciation of methodology and the nature of the learning process. We would like to see more of a commitment to the desirability of shaping growth in our pupils in such a way as to promote the ability to adapt to the pace, changing conditions, and demands of today's world. My Government sees science education containing materials and ideas that will help our students to facilitate transferability of knowledge, flexibility of thinking, tolerance of differing points of view, and the ability to accurately distinguish between the relevant and the irrelevant.

We are accountable to our society to see that students are prepared to deal with the ever present challenges that will confront them, whether these be social, intellectual or vocational.

A course in Science may be successful only if it affects a person so that he develops a true scientific attitude. A person who has developed such an attitude reacts toward his environment in distinct ways - ways totally different from those of a person who has no understanding of scientific value.

Today, I am extremely proud and my Government is grateful that such an esteemed body as the Commonwealth Secretariat has chosen our country to hold such an important regional workshop as this one. We are happy to play host and we are sure that all of our people will continue to give you the Bahamian hospitality that we are famous for - friendliness, warmth, and our sea, sun and sand. I hope that some of our sand will remain in your shoes and you will return to our lovely country in the very near future. May your work, discussions and social inter-mingling be productive and fruitful during the two weeks of this workshop.

It is my pleasure now to officially declare the Commonwealth Caribbean Regional Seminar/Workshop on Low-Cost Teaching Equipment open.

SPEECH BY DR. S.J. COOKEY

DIRECTOR, EDUCATION DIVISION, COMMONWEALTH SECRETARIAT

It gives me much pleasure to be here once again in this lovely country of the Bahamas. I believe I am here now because, as the saying in the Bahamas goes, I "took away some sand in my shoes" when I visited this country in 1974. On this memorable occasion my primary task is to thank the Honourable Minister and the Government and people of the Bahamas for their kindness and hospitality. However, before I do that I think it would be appropriate to say a few words about the Commonwealth, the Commonwealth Secretariat, and this Seminar/Workshop on Low-Cost Science Teaching Equipment.

My first contact with the Bahamas was in Nairobi, Kenya, in 1973. At the time, both the Honourable Coakley and I were in Kenya attending a Commonwealth Secretariat Conference on "Teacher Education in a Changing Society". We were both accommodated in the Panafric Hotel. A day or two after we had been in that hotel, we began to run into some difficulties. I discovered that from time to time some Coakley notes got into the Cookey pigeonhole, and vice versa. In short, the receptionists and stewards at the hotel remarked that they could hardly tell the difference between "Coakley" and "Cookey". I dare say I have enjoyed the same experience twice since I arrived here two days ago. On arrival at Nassau airport the first remarks I heard was "Gosh, he looks like Mr. Coakley". This morning I heard someone say that when she saw me coming to the reception desk, she ran out of the room thinking that the Minister had arrived at the hotel. Well, something ought to be done; either Coakley goes back to whence he came to the Bahamas, or Cookey comes to live in the Bahamas.

I should like to say a few words about the Commonwealth itself. I sometimes find it difficult to talk about the Commonwealth without causing confusion among my audience, when I am in Australia or in the Bahamas. This is because both countries refer to themselves as a Commonwealth. On this occasion, the Commonwealth I would like to talk about is the one which the Chairman, Mr. Bethel, has defined so well. This is the Commonwealth of nations, a voluntary association of independent sovereign states with their dependencies and associated states and protectorates. This is a Commonwealth which is currently made up of 36 sovereign countries, Seychelles being the latest member. Its population of some 90 million is scattered over a total land area of 10 million square miles.

The distinguishing feature of the Commonwealth is the harmony with which the members work. During frequent consultations among members, decisions are reached by consensus rather than by voting. Member governments express their views frankly, sometimes with some heat, but in the end consensus is reached, decision taken and ways of promoting Commonwealth co-operation are sought. This indeed is a Commonwealth which everybody here, I am sure, would like to see maintained and encouraged.

The Commonwealth Secretariat was established by Commonwealth Heads of Government in 1965. Its first Secretary-General was a Canadian, Mr. Arnold Smith, who held the post until July 1975 when he was succeeded by

a Caribbean, Mr. Shridath Ramphal. The main function of the Secretariat is to promote Commonwealth co-operation. Its common policy is carried out through the activities of a number of Divisions: for example, Education, International Affairs, Health, Administration, Legal Affairs, and Food Production and Rural Development.

In 1971 the role of the Secretariat was given a new dimension with the setting up, by the Commonwealth Heads of Government, of the Commonwealth Fund for Technical Co-operation. This is a Fund to which members contribute voluntarily. It is in fact money from the Fund which has made it possible for us to hold this Seminar. Prior to the establishment of this Fund it was not possible, because of the lack of funds, to implement many of the decisions that had emerged from the various Commonwealth meetings that had taken place. This important Fund, known as CFTC, for short, is functioning very well because of the generosity of the member countries who contribute so liberally to it.

Next, let me say a few words about the Education Division of the Commonwealth Secretariat. Years ago the main activity of this Division was to organize meetings of Commonwealth Ministers of Education. The first of such conferences took place in Oxford in 1959. The latest meeting, the Sixth, was held in Kingston, Jamaica in 1974. We have just learnt that the Government of Ghana has accepted our invitation to host the Seventh meeting in Accra in March 1977. In addition to the Conference of Ministers of Education, we also organize meetings referred to as "Specialist Conferences". These Specialist Conferences, which are held in between conferences of Ministers, bring specialists together to discuss a major theme in education. I have already referred to the 1973 Specialist Conferene on "Teacher Education in a Changing Society". The latest Specialist Conference took place in New Zealand in 1975. The theme for that conference was "Materials for Learning and Teaching", a subject which is not much different from the theme of our present seminar.

Our new emphasis now is on seminars and training workshops. This is because we believe that the ultimate purpose in discussing a subject is to arrive at practical ways by which we could solve problems. We believe that one reason why many recommendations resulting from Commonwealth meetings are not implemented at the national level is that there is not a sufficient number of trained personnel in those fields. I am happy to say that we have embarked on a programme of regional training courses to help meet this need. The first of a number of such courses will begin in Nairobi in Kenya in January 1977. It will be a three-month training exercise in educational administration and supervision. Participants at this course will include principals, headmasters, inspectors and supervisors of schools. The Nairobi course will, sometime in the latter part of 1977, be followed by a Caribbean course on certain aspects of book production to be held in Guyana. We shall continue to organize these regional courses if demands for them continue.

Our objectives for the Seminar/Workshop that is about to begin reflect the present orientation of the educational programmes of the Commonwealth Secretariat. Among these obejctives are:

> to provide workshop experience in designing, developing and evaluating locally-constructed low-cost science teaching equipment; to consider the implications for teacher education if teachers are to participate meaningfully and effectively in innovative strategies of teaching using low-cost science teaching equipment; to determine ways of improving Commonwealth co-operation in the interchange of ideas

and experience in the development and production of school science equipment.

That this is a very important meeting cannot be overemphasized. The Honourable Minister of Education made this clear in his speech when he referred to the increasing importance of science to national development and told us what his country is doing in the field of science education. Many countries are unable to offer science education at the high school level. It is not surprising, therefore, that at the primary school level, science teaching is at present seen by some people as a luxury. It is true that one reason for this state of affairs is the shortage of adequately trained teachers. But even if the teachers were in good supply, there is an acute shortage in many countries of the science teaching equipment necessary to make science teaching effective through student participation in practical, problem-solving activities. Many school administrators are scared by the high cost of the traditional, usually imported, school science equipment and, faced with the financial constraints imposed on the school system, often prefer not to introduce science as a subject. Where science is taught it often takes the form of students' memorizing scientific facts.

The purpose of this seminar is to show that we need not have a great deal of money before we begin to teach science at the primary and secondary school levels. Most of the essential items of equipment required for science teaching can be produced locally, often at a fraction of the cost of importing them from other countries. Science can be taught effectively using cheap locally-produced equipment. This is not merely a belief. It is a fact which has been demonstrated by India, Sri Lanka, Kenya and other countries which have had the courage to start local production of school science equipment. This meeting affords us the opportunity to see how Caribbean countries can go into local production in order to help spread the knowledge of science to all their school children.

This is the age of science and technology. We often complain that we have to rely upon foreign expertise to operate our industries. There is shortage of local personnel to run our industries because we do not have an infrastructure for training our own scientists, technicians and technologists. The few engineers that developing countries have cannot work effectively without the support of technicians. It has been found that an engineer is most productive when he is assisted in his work by five to eight technicians. The number of people available to train as technicians and technologists depends on the number of school children who have basic knowledge of science. No country can therefore afford, in this present age, to continue to live comfortably if it neglects to inculcate in its children what the Honourable Minister referred to as "scientific attitude".

Now, Mr. Chairman, on behalf of the Commonwealth Secretary-General and on my own behalf I should like to thank all those who have helped to bring about this meeting. I should like to begin with the Government and the people of this beautiful country. I was thrilled by the enthusiasm with which our invitation to host this meeting was accepted, at a very short notice, by the Government of the Bahamas. The arrangements for this meeting could not have progressed so smoothly but for the active co-operation of the Honourable Minister of Education and Culture, the Honourable Mr. Coakley, the Permanent Secretary, Mr. Baltron Bethel, the former Director of Education, Mr. Gurth Archer, and the staff of the Ministry. The preparation for this meeting has been thorough and the reception given to us participants has been wonderful. Thank you all for this excellent support.

Finally, I am happy to welcome all participants - delegates from Commonwealth Caribbean countries, consultants, resource personnel, and observers - to this important seminar/workshop. I hope you have had a pleasant journey and that you will find your stay here enjoyable. I have no doubt that you have come here determined to make a contribution to the success of this meeting. To delegates, in particular, I should say that it is my hope that your active participation at this meeting will help stimulate the production of science teaching equipment in your countries, and thereby help spread the knowledge of science to all children in the Caribbean.

SPEECH BY THE HONOURABLE

PAUL L. ADDERLEY MINISTER OF EXTERNAL

AFFAIRS AND ATTORNEY GENERAL AT THE CLOSING SESSION

We in the Commonwealth of the Bahamas have been honoured to host this Commonwealth Caribbean Regional Seminar/Workshop on Low-Cost Science Equipment to which the response has been most encouraging in that fourteen territories have sent delegates.

The Commonwealth Secretariat has organized this seminar as part of its efforts to assist Commonwealth countries to make science teaching more effective and less costly through the use of simple equipment that can be made locally and within the region.

The importance of science education in the world today cannot be overemphasized, and it is presumed that the Commonwelath Caribbean governments would wish to have their science programmes expanded and made more effective.

Having regard to what I understand has been stated by the delegates and by the Seminar Director, Dr. S.J. Cookey, the need for the teaching of science in all schools has been stressed both in the country papers and in the deliberations of the Seminar. It would seem that the activities of these past ten days have contributed much in helping to raise the comparatively low priority level of science in educational systems to a level befitting the scientific and technological era in which we live. In order to achieve social and economic development, a country must have a good foundation in Science but the theoretic teaching of the subject, which perhaps has been too often the case, cannot produce technicians and technologists.

I believe that such development can only take place by the application of scientific and technological techniques in industry, in agriculture and in fisheries to enable all our countries to develop the heretofore unexploited, inadequately exploited or improperly exploited land and natural resources which we possess.

It is an economic fact of life, which is not peculiar to those of us who belong to small states in this region, that there are constraints upon development in states which have limited land resources, limited water resources and lack large consumer markets. We must therefore be constantly mindful of all the factors that affect our economic viability. Politicians and planners are therefore faced with problems.

How far, for example, are physically powerless states free to restructure their economies without interference from external forces? Can they survive as entities in their own right instead of being regarded as client states with varying degrees of dependence on metropolitan governments or interests? Can such states be self-sustaining? Can their economies meet the basic needs of their populations? Can their economies provide efficient job opportunities?

Answers have to be found with your assistance; answers which are consistent with the maintenance of national sovereignty and independence. I draw attention to these considerations because it is in thier context that meetings such as yours have meaning.

The purpose of this Seminar/Workshop, as I understand it, was to provide an opportunity for participants to exchange views and information on the matter of the provision of equipment in Commonwealth Caribbean territories and to come up with some practical solutions. I am led to believe that you have achieved your task to some degree, for although it may not be possible to come up with answers to all the problems the opportunity has been given to grapple with them. The results of your deliberations are embodied in your report, and as you return to your respective countries the onus is upon you to ensure that your governments receive adequate and relevant information to support the efforts of this Seminar. One of the recommendations is that governments should be requested to give support and approval to programmes relating to the teaching of science in a number of ways, among them being the establishment and strengthening of national curriculum units which might assist in the production of school science curricula. A second is that they should undertake feasibility studies with regard to the production of equipment both at local and regional level to support such curricula. Other aspects to be considered under government action would be the allocation of adequate funds for equipment and for the training of personnel to produce equipment and the training of teachers in the use of whatever is produced.

In a seminar of this nature, when so many territories are represented, aspects of regional co-operation are topical. I understand that in your deliberations the need for regional co-operation has been recognized and that it could take the form of exchanging information. The co-operation might be bilateral, sub-regional or regional. The important point is that inter-Caribbean communication has been set in motion, and the task ahead is to pursue action at all possible levels. As a result of co-operative efforts, groups of territories may feel that they can readily formulate plans for the execution of specific projects based on recommendations of this Seminar.

I wish to touch upon the question of the feasibility of producing low-cost science equipment. I have been informed that some matters of concern which arose from this seminar were the high cost of purchasing production equipment because of the small market in the area and the ultimate goal establishing regional production units which would produce equipment in the quantity required. Certain difficulties have been recognized such as: (a) Customs duty on goods imported from other countries within the region; (b) The high cost of transportation; (c) Lack of agreed curriculum for primary science teaching. In this respect, I would suggest that it might be helpful if the Education desk of the CARICOM Secretariat could serve as a clearing-house of information on science teaching as well as general education.

I take this opportunity to express our appreciation to the Commonwealth Secretariat for having arranged this Seminar for the Commonwealth Caribbean. I understand that this is the first in a series of seminars relating to the teaching of science, and we are all the more pleased that the Commonwealth of the Bahamas has been chosen as the venue. As the Ministry of External Affairs of the Bahamas is charged with the responsibility of co-ordinating technical assistance from external bodies, I would also like to express the Government's appreciation for the significant assistance in broadening the range of areas being provided to the Bahamas and other Commonwealth countries through the Commonwealth Secretariat.

ORGANIZATION OF SEMINAR/WORKSHOP

AGENDA

Theme

The theme of the seminar/workshop was "The Production, Use and Management of Low-Cost Science Equipment".

Objectives

(a) To consider methods by which school science equipment is most effectively developed through greater involvement with curriculum innovators and school teachers, in order to fulfil curriculum objectives;

(b) to examine the role of teachers, instructors, technicians and the community in the development and production of low-cost science equipment;

(c) to consider the implications for teacher education if teachers are to participate meaningfully and effectively in innovative strategies of teaching using low-cost science teaching equipment;

(d) to provide workshop experience in designing, developing and evaluating of locally constructed low-cost science teaching equipment;

(e) to determine ways of improving Commonwealth co-operation in the interchange of ideas and experience in the development and production of school science equipment.

Agenda Item I: The Potential for Local Manufacture of School Science Equipment, and Problems of Equipping School Laboratories

(a) Present source of equipment and evaluation;

(b) Difficulties and problems with equipping schools with suitable equipment;

(c) Existing local resources. Types of science equipment that can be produced locally and cheaply;

(d) Contribution of teachers, instructors, technicians and the community in the production, distribution, routine maintenance and evaluation of school science equipment;

(e) Setting up of experimental units for the production of science equipment at various levels (in schools, technical colleges, in villages or cities in collaboration with local artisans, semi-industrial or industrial scale).

Agenda Item II: The Design, Development and Production of Low-Cost Science Equipment

(a) Ideas for design or equipment; the role of curriculum development bodies, research units, science teachers' associations etc. at sub-national and national levels. Devising strategies to improve interaction;

(b) Design, production and evaluation centres: their function and basic equipment; standards and methods of testing and reporting; recognition of needs of handicapped learners.

Agenda Item III: The Organization and Management of School Science Equipment

(a) The development and management of equipment centres (staffing, accessibility to users, storage, distribution);

(b) Supply, maintenance and support services (equipment, repair and replacement);

(c) Designs for estimating cost-effectiveness.

Agenda Item IV: The Use of Low-Cost Science Equipment in Schools

(a) Individual student experimentation;

(b) Teacher demonstration exercises;

(c) Storage;

(d) Maintenance and repairs;

(e) Administrative programmes to ensure that teachers actually make use of equipment and use the equipment effectively;

(f) Evaluation of equipment by teachers.

Agenda Item V: Programme of Training and Supervision for the Efficient Use of Equipment; and the Dissemination of Information Relating to their Use

(a) National Training Centres;

(b) In-service training at local level (for teachers and technicians);

(c) Networks for dissemination of information on successful utilization of local materials.

Agenda Item VI: Practical Laboratory Sessions

Agenda Item VII: Commonwealth Co-operation in the Manufacture, Supply and Use of Low-Cost Science Equipment

(a) Exchange of information;

(b) Regional agencies for training: visits and attachments.

TIMETABLE

Date (Day)	9.00 - 10.30	11.00 - 12.30	14.00 - 15.30	16.00 - 17.30
15 November (Monday)	REGISTRATION OF PARTICIPANTS			
16 November (Tuesday)	OPENING CEREMONY		Plenary I Country Papers	Plenary II Country Papers
17 November (Wednesday)	Plenary III Leads 1 and 4	Groups I Leads 1 and 4	Groups II Leads 1 and 4	Groups III Leads 1 and 4
18 November (Thursday)	Plenary IV Lead 2	Groups IV Lead 2	Groups V Lead 2	Laboratory I
19 November (Friday)	Laboratory II	Laboratory III	Plenary V Report Leads 1 and 4	Plenary VI Report Lead 2
20 November (Saturday)	Laboratory IV	Laboratory V	F R E E	F R E E
21 November (Sunday)	F R E E	F R E E	F R E E	F R E E
22 November (Monday)	Plenary VII Lead 3	Groups VI Lead 3	Groups VI Lead 3	Laboratory VII
23 November (Tuesday)	Plenary VIII Lead 5	Groups VII Lead 5	Groups VIII Lead 5	Plenary IX Report Lead 3
24 November (Wednesday)	Visit to Schools	Visit to Schools	Plenary X Report Lead 5	Plenary XI Lead 6
25 November (Thursday)	Laboratory VIII	Laboratory IX	Laboratory X	Laboratory XI
26 November (Friday)	F R E E	F R E E	Plenary XII Adoption of Seminar/ Workshop Report	CLOSING SESSION

LABORATORY PROGRAMME

Objectives

(a) To familiarize participants with what can be done with limited resources;

(b) To familiarize participants with basic workshop techniques and economies;

(c) To encourage participants to see the development of low-cost equipment as an integral part of the teaching strategy;

(d) To encourage participants to see to what extent they could participate in the local production of science equipment;

(e) To encourage participants to construct simple equipment (both software and hardware).

Programme

(a) Laboratory I - An introductory session at which the Kenya Science Equipment Production Unit (SEPU) kits and the National Council of Educational Research and Training (NCERT) kits or equipment to be demonstrated. Simple experiments to be set up to familiarize participants with the practical problems that arise during construction and use of low-cost science equipment.

(b) Laboratory II - Analytical discussion of the SEPU kits. Preparation of guidelines for the remaining laboratory sessions.

(c) Laboratory III-IX - Participants to be divided into four to six groups to review certain sections of the West Indian Science Curriculum (WISC) programme.

In order to acquire basic practical workshop techniques and experience in equipment production, each group is to develop its own plan taking into account:

- (i) apparatus requirements for the chosen section of the WISC syllabus;
- (ii) the printed material necessary to support the hardware; and
- (iii) support material e.g. slides, radio scripts etc. which would be required.

(d) Laboratory X-XI - Presentation of completed work for total group appraisal and preparation for exhibition of materials developed.

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